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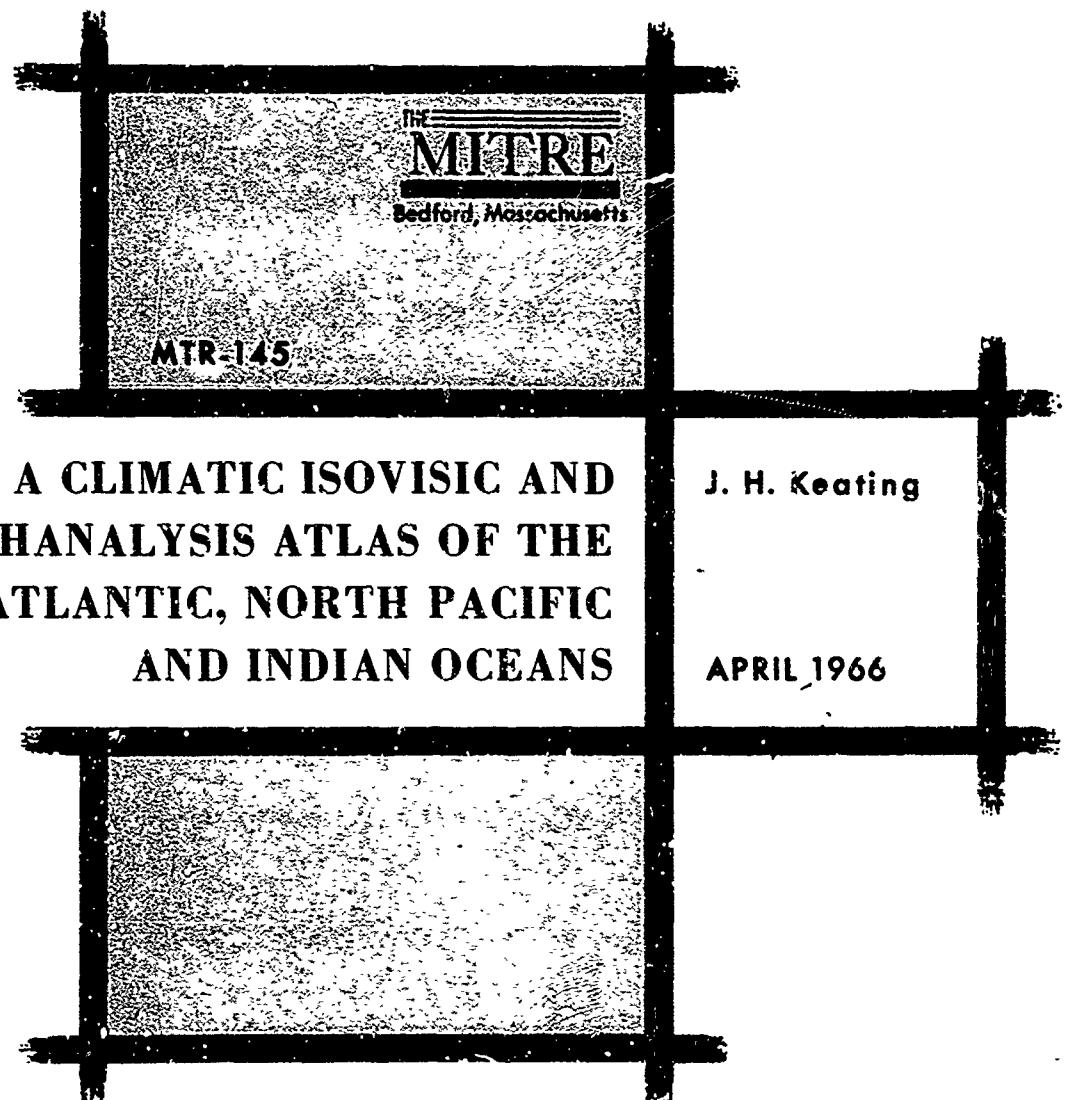
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MITRE Technical Report

MTR- 145- No. Vol. Series Rev. Supp. Corr.

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Subject: A Climatic Isovisic and Nephanalysis
Atlas of the North Atlantic, North
Pacific and Indian Oceans

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Page 1 of 154 Pages

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ABSTRACT

In support of the NRDL Optical Sensor Study climatological charts are provided for the mid-season months of January, April, July and October for the North Atlantic, North Pacific and Indian Oceans. The climatological charts provide:

- a. Isovistic (visibility) maps of the percentage frequency of visibilities less than 25, 10, five, two and one nm.
- b. Isovistic maps of visibility for 90 percent, 75 percent, 50 percent and 25 percent.
- c. Nephanalysis maps of the percentage frequency of total cloud cover greater than or equal to seven eights ($\geq 7/8$).
- d. Nephanalysis maps of percentage frequency of total cloud cover equal to or less than two tenths ($\leq 2/10$).

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SECTION I
INTRODUCTION

This atlas has been prepared in support of the Optical Environmental Study conducted by the MITRE Corporation for the Naval Research Devense Laboratory (NRDL). The climatological analysis presented in ths paper is intended to support the atmospherinc transmission task of the study but is provided in a format that is generally applicable to a wide range of naval engineering and operational planning activities.

The study provides a climatological analysis of visibility and total cloud cover for each of the mid-season months of January, April, July, and October. The geographical areas of interest were selected based upon their significance to naval operations. They are the North Atlantic Ocean, the North Pacific Ocean, and the Indian Ocean.

SECTION II

METEOROLOGICAL VISIBILITY

Middleton (Reference 1) has summarized the meteorological visibility observation technique as follows: "Visibility is the greatest distance in a given direction at which it is just possible to see and identify with the unaided eye: in the daytime a prominent dark object against the sky at the horizon; and at night, a known preferably unfocused, moderately intense light source. After visibilities have been determined around the entire horizon circle, they are resolved into a single value of prevailing visibility for reporting purposes."

The directives for the observation and encoding of visibility are contained in the Manual of Surface Observations (WBAN), "Circular N," and are consistent with the international procedures coordinated through the World Meteorological Organization (WMO). "Circular N" defines the prevailing visibility as the greatest visibility which is attained or surpassed throughout half of the horizon circle, not necessarily continuous. Under non-uniform conditions, the sectors may be distributed in any order. Under uniform conditions, the prevailing visibility is the same as the visibility in any direction. If the visibility is variable, i.e., the prevailing visibility rapidly increases and decreases one or more reportable value during the period of observation, the average is used.

The meteorological visibility observation is intended for visual range estimates over flat horizontal paths only and, because of the general lack of uniformity of the atmosphere in the lower levels, it is not a reliable indicator of the slant range visibility.

RELIABILITY OF VISIBILITY OBSERVATIONS

The observation of meteorological visibility is highly subjective. Inland and coastal stations have an advantage in having fixed objects and light sources at known distances to help determine visual range.

Ships at sea have neither reference markers nor trained observers. Although no quantitative analysis has been made, it may be assumed that during daytime, ship visibility observations are probably overestimated for the short visual ranges (less than three miles), and underestimated for longer distances.

A major area of concern is night time observations at sea. Without moonlight, observation is practically impossible. The acceptable practice is to continue to record the last valid visibility observation until such time as there is sufficient light to observe a change. The diurnal variation of visibility over the ocean is probably negligible because diurnal variations in the thermal stratification are small and thus, little diurnal change in the wind or aerosol distribution is expected.

ISOVISIC ANALYSIS

The term "Isovisic" (adjective Isovistic) was coined by Eldridge (Reference 2) to describe the analysis of visibilities to provide lines of constant visibility.

An isovisic chart is based upon the assumption that visibility is a conservative parameter with respect to space or time. While it is very difficult to validate the conservation between observational points with "real-time," synoptic data, the statistical nature of climatological visibility data lends itself to such an analysis.

SECTION III

NEPHANALYSIS

A nephanalysis is a cloud cover analysis resulting in contours of equal cloudiness or percentage frequency of selected cloud cover intervals. The percentage frequency of cloud cover for amounts less than or equal to two tenths, and for amounts greater than or equal to seven eights, is provided to supplement the visibility data in the evaluation of transmissivity.

Cloud observation procedures are standarized in "Circular N." Observational bias can be expected due to the difficulty of distinguishing between cloud sides and cloud bottoms at low angles of view. The bias is generally one of overestimating the percentage of cloud cover.

SECTION IV

GEOGRAPHICAL AREAS STUDIED

Based upon the validity and reliability of the available climatological studies and upon a determination of areas of operational significance an analysis was made of three ocean areas. The areas and principle reference documents are as follows:

- a. North Atlantic - U.S. Navy Marine Climatic Atlas of the World, Volume I, North Atlantic Ocean, NAVAER 50-IC-528, 1 July 1956.
- b. North Pacific - U.S. Navy Marine Climatic Atlas of the World, Volume II, North Pacific Ocean, NAVAER 50-IC-529, 1 July 1956.
- c. Indian Ocean - U.S. Navy Marine Climatic Atlas of the World, Volume III, Indian Ocean, NAVAER 50-IC-530, 1 September 1957.

For each of the oceanic areas, the NAVAER Climatic Atlas provides cumulative percentage frequency distributions of horizontal visibility and total cloud cover for approximately 50 data points. Figures 1 through 3 illustrate the data points from coast and island stations, ocean stations (weather stations) and small ocean areas representative of a relatively homogeneous climatic region. Areas where the climatological data is scarce are identified as jagged boxes.

The number of observations used in the NAVAER series to provide the percentage frequency distributions is unknown but includes all the available data from the National Weather Records Center, Asheville, North Carolina.

Over the Indian Ocean dashed contours have been used to indicate areas requiring more subjective analysis due to the availability or reliability of the data.

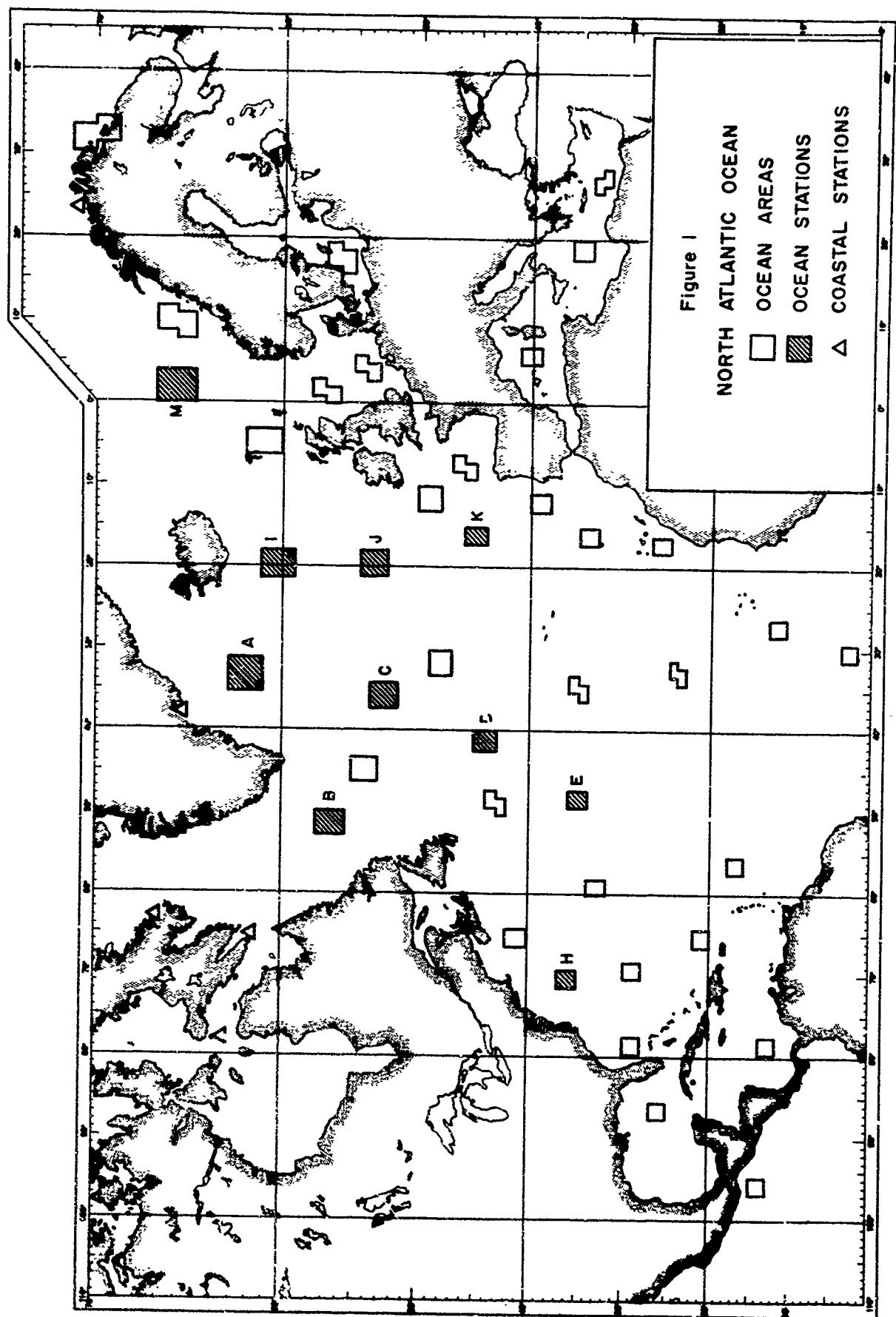


Figure 1
NORTH ATLANTIC OCEAN

□ OCEAN AREAS
▨ OCEAN STATIONS

△ COASTAL STATIONS

Figure 2

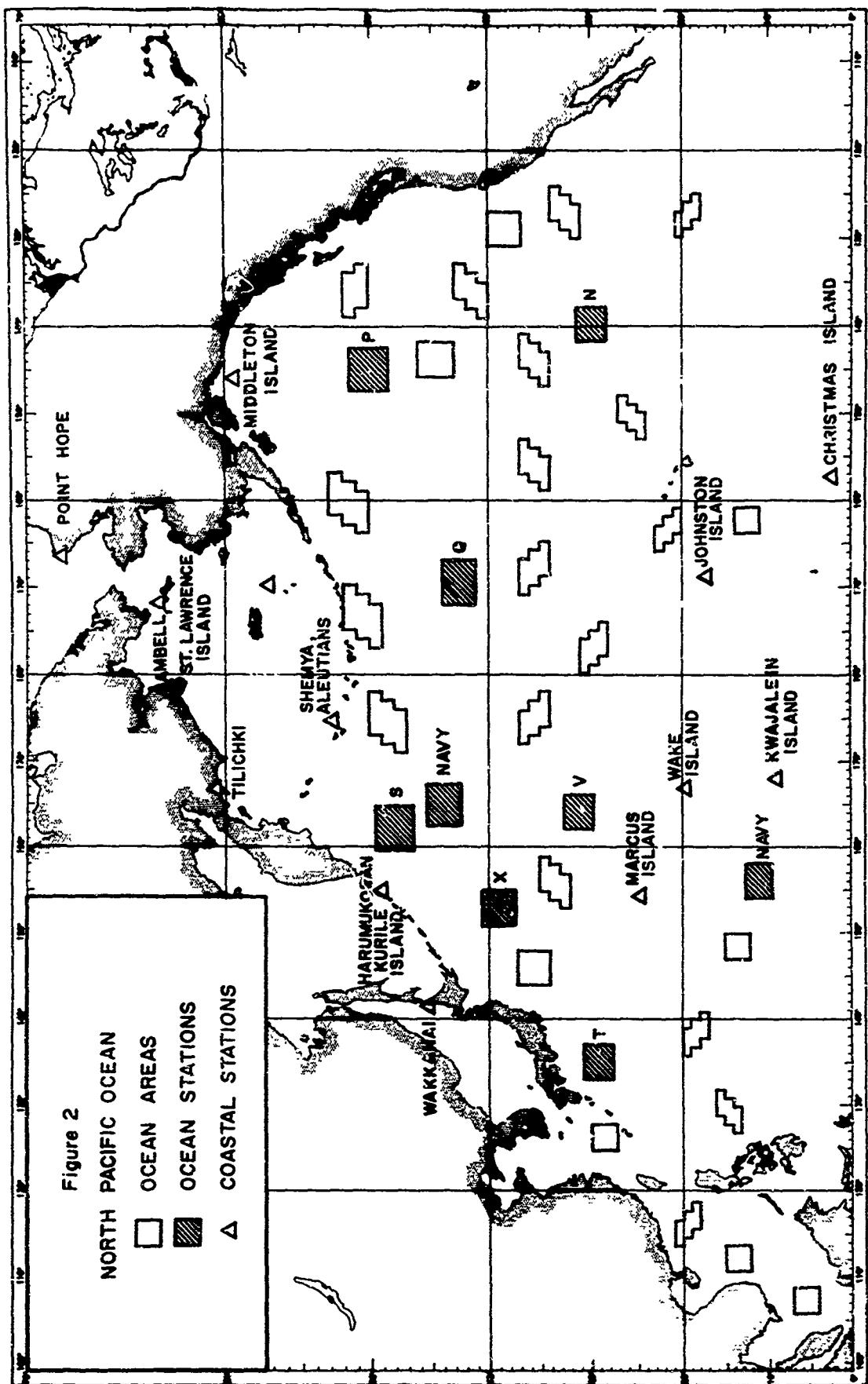
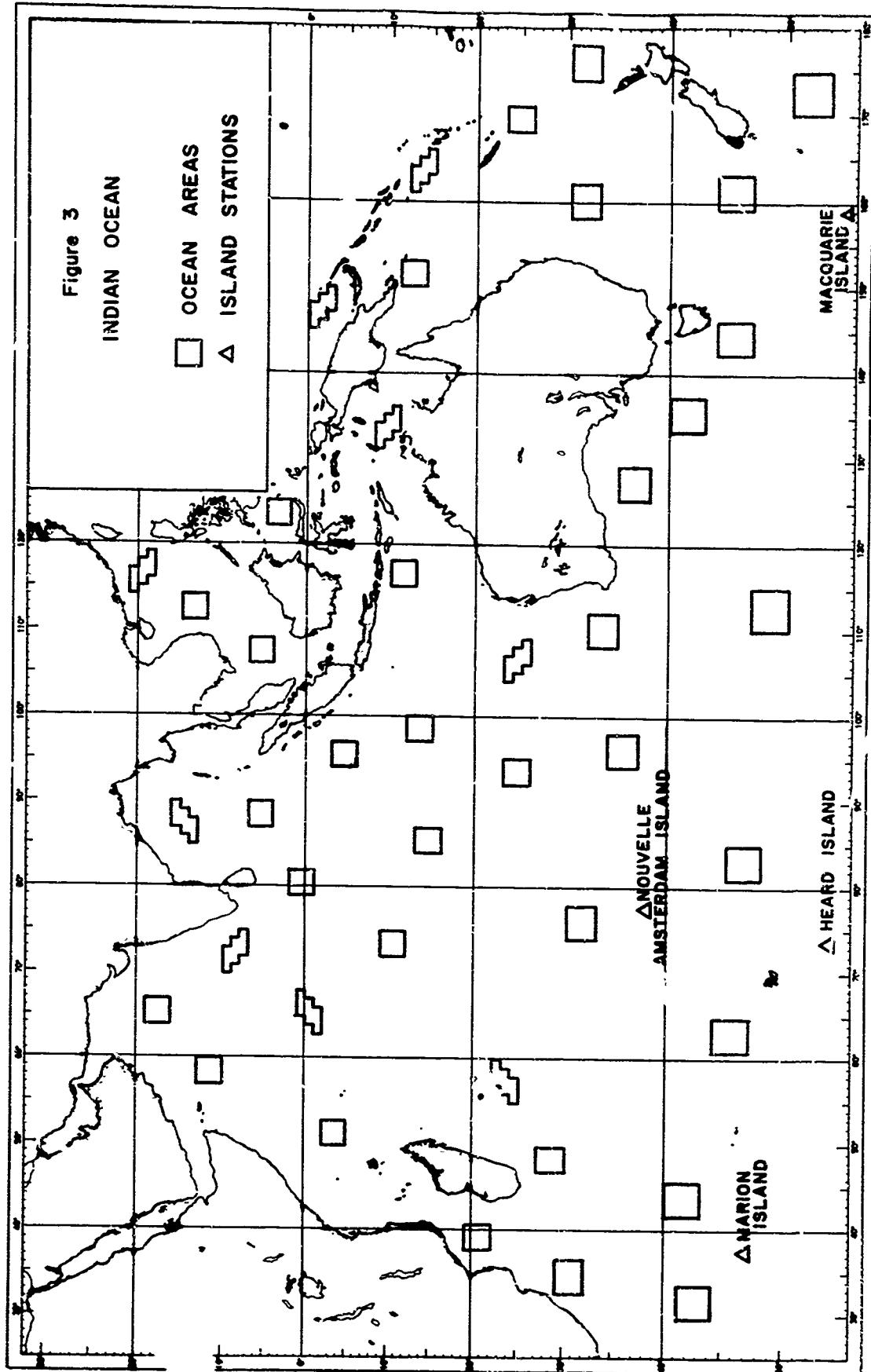


Figure 3

INDIAN OCEAN

□ OCEAN AREAS
△ ISLAND STATIONS

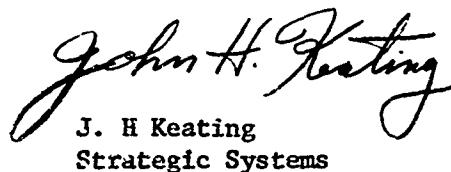


SECTION V

DESCRIPTION OF THE ANALYSIS

For each of the three geographical areas and for the mid-season months of January, April, July, and October, the visibility and cloud cover analysis is present in four basic forms, each form in a separate Appendix as follows:

- a. Appendix A - Isovistic maps providing contours of percentage frequency of the visibility falling into one of the following five categories: less than 25 nm, less than 10 nm, less than 5 nm, less than two nm, and less than one nm.
- b. Appendix B - Isovistic maps providing contours of visibility for each of four categories of probability; 90 percent, 75 percent, 50 percent, and 25 percent.
- c. Appendix C - Nephanalysis providing contours of percentage frequency of total cloud cover greater than or equal to seven eights ($\geq 7/8$).
- d. Appendix D - Nephanalysis providing contours of percentage frequency of total cloud cover equal to or less than two tenths ($\leq 2/10$).



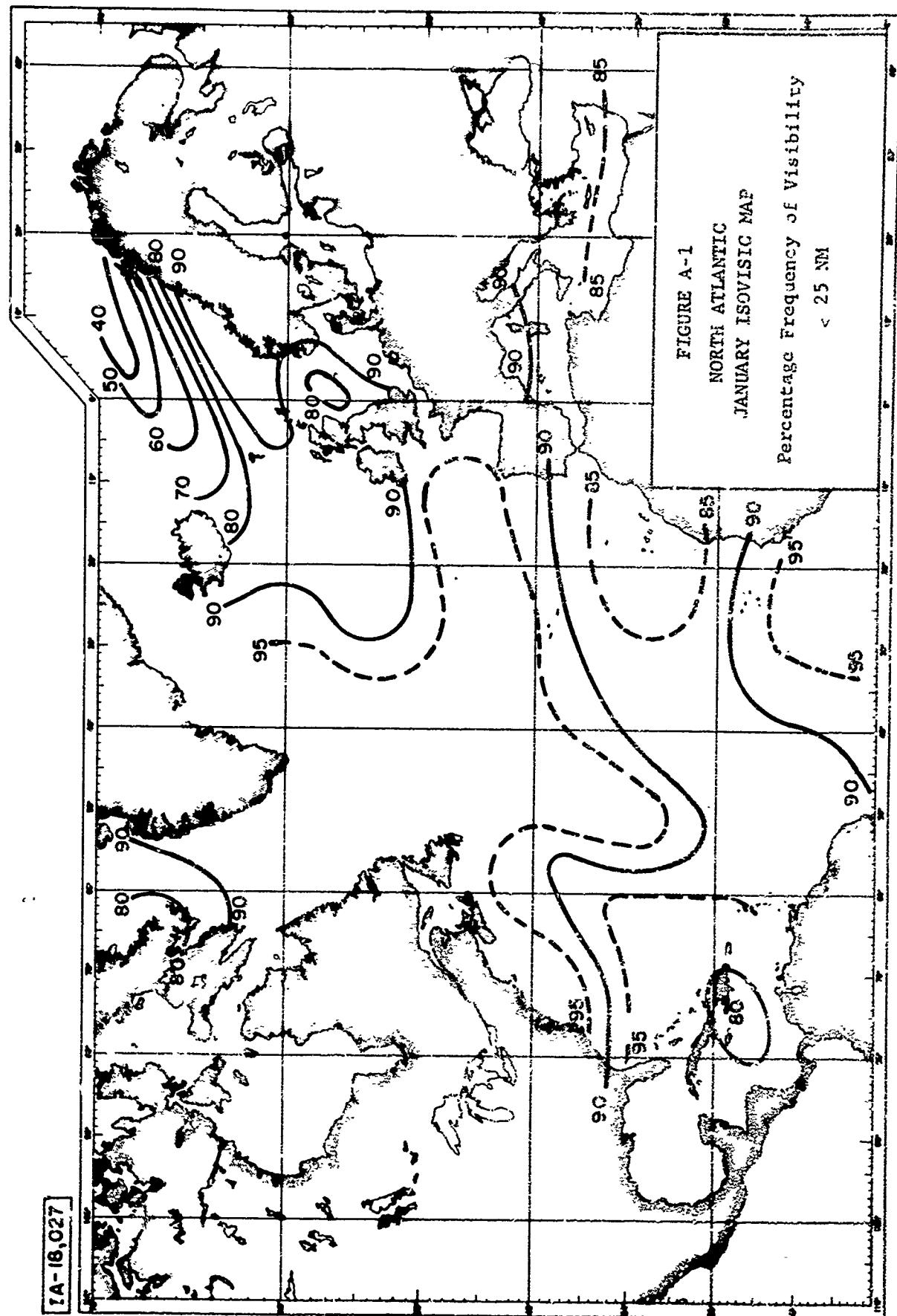
John H. Keating
J. H Keating
Strategic Systems

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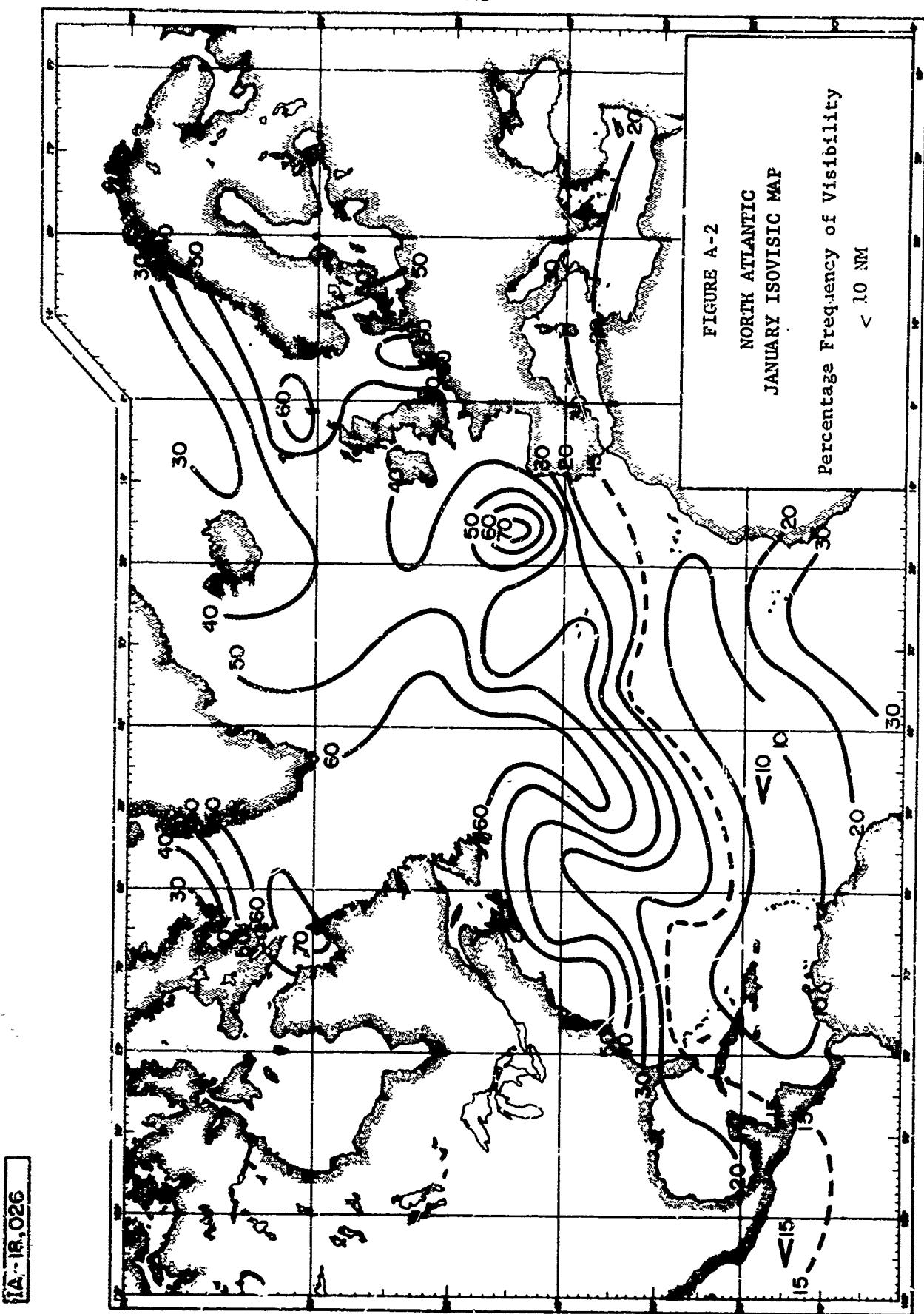
APPENDIX A

**ISOVISIC MAPS - PERCENTAGE FREQUENCY OF VISIBILITIES LESS
THAN 25, 10, five, two and one Nautical Miles**

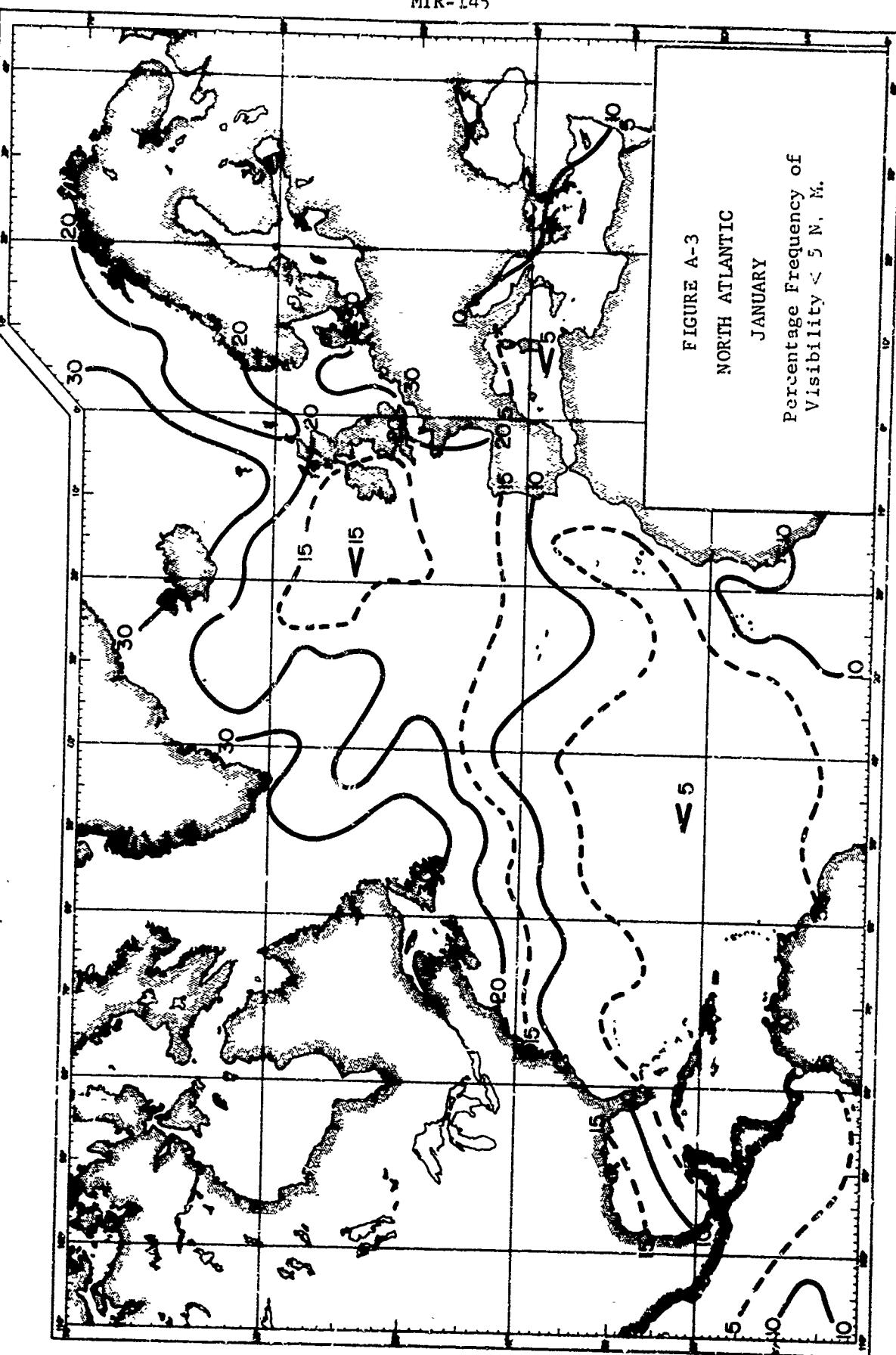
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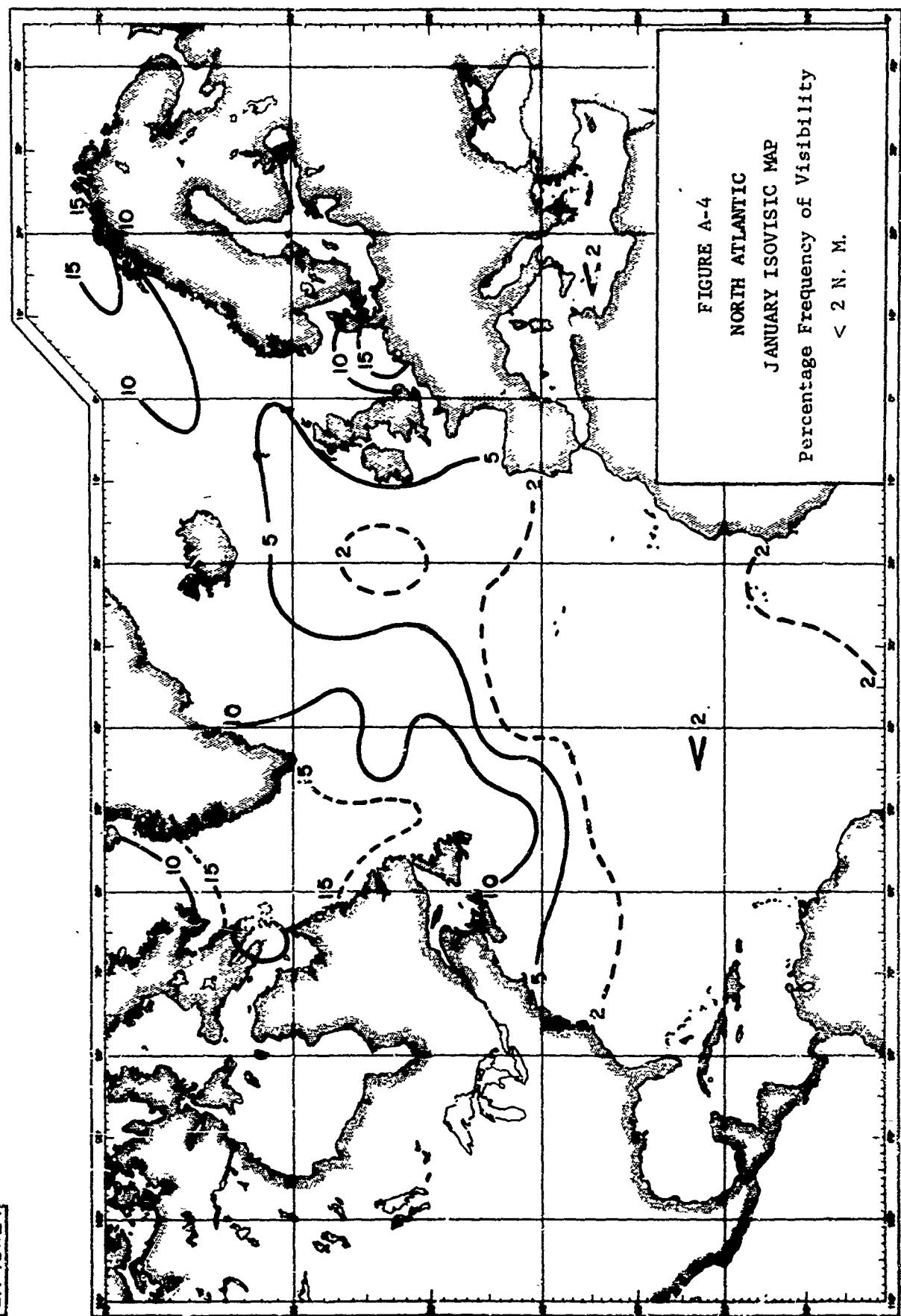


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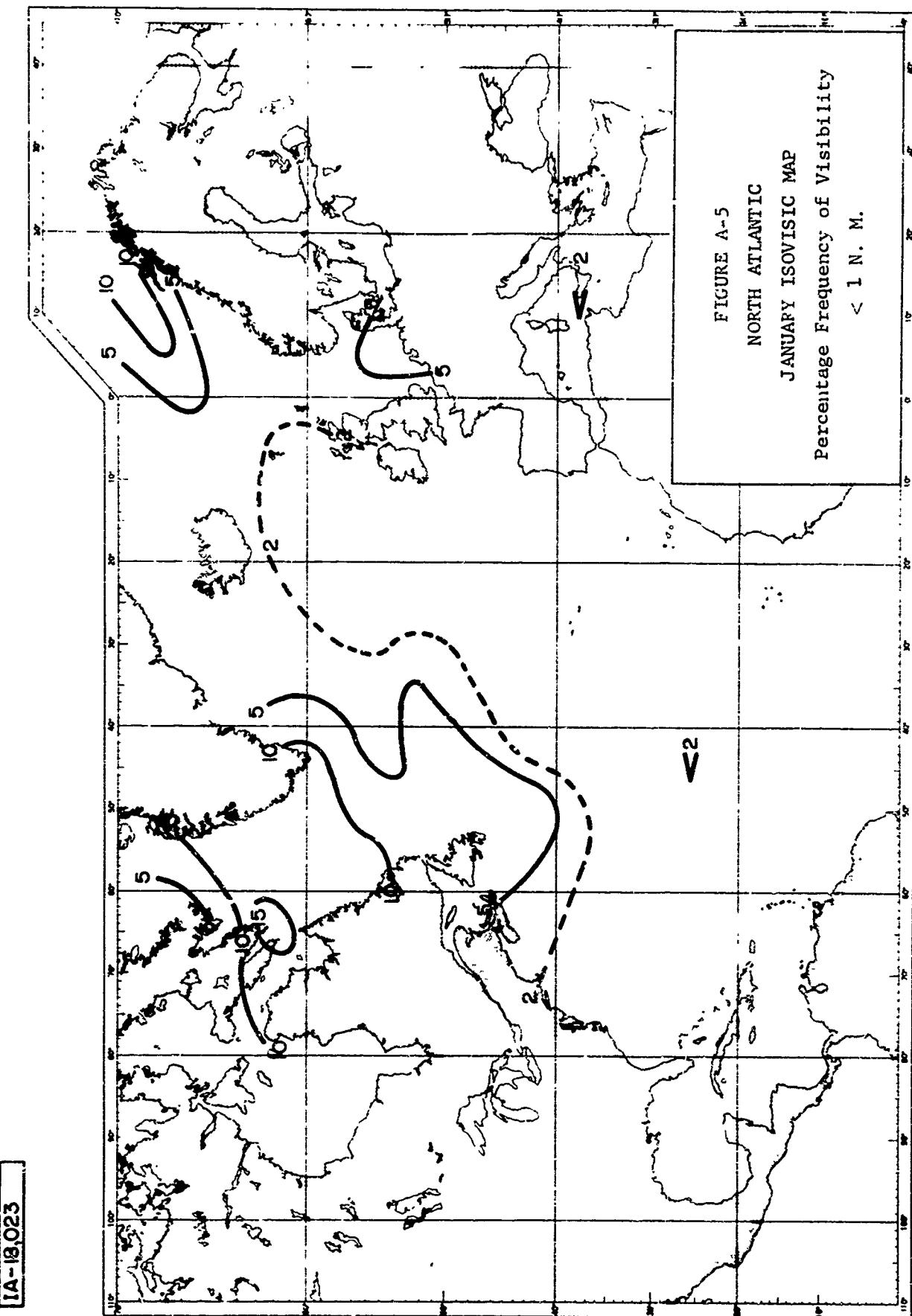


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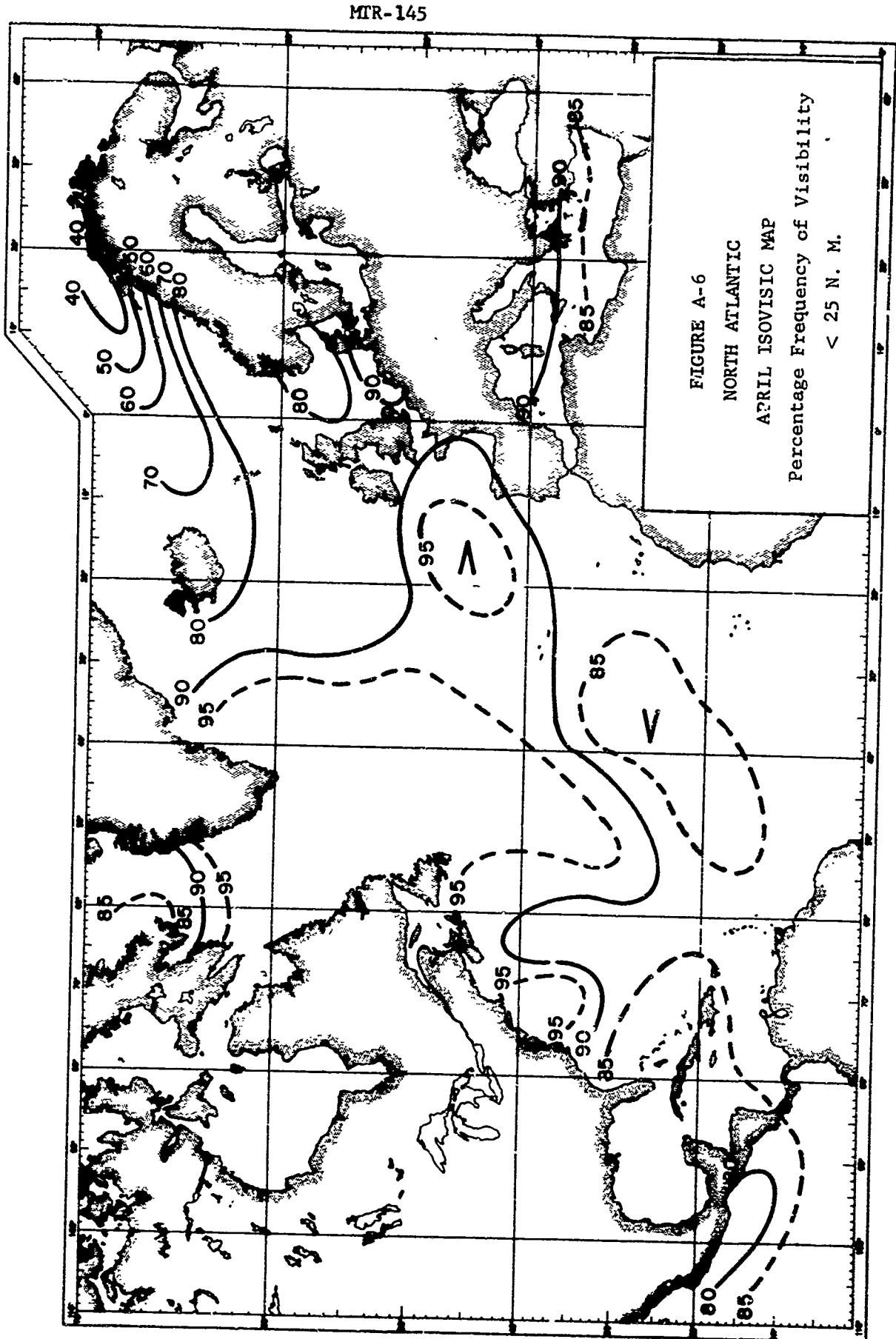


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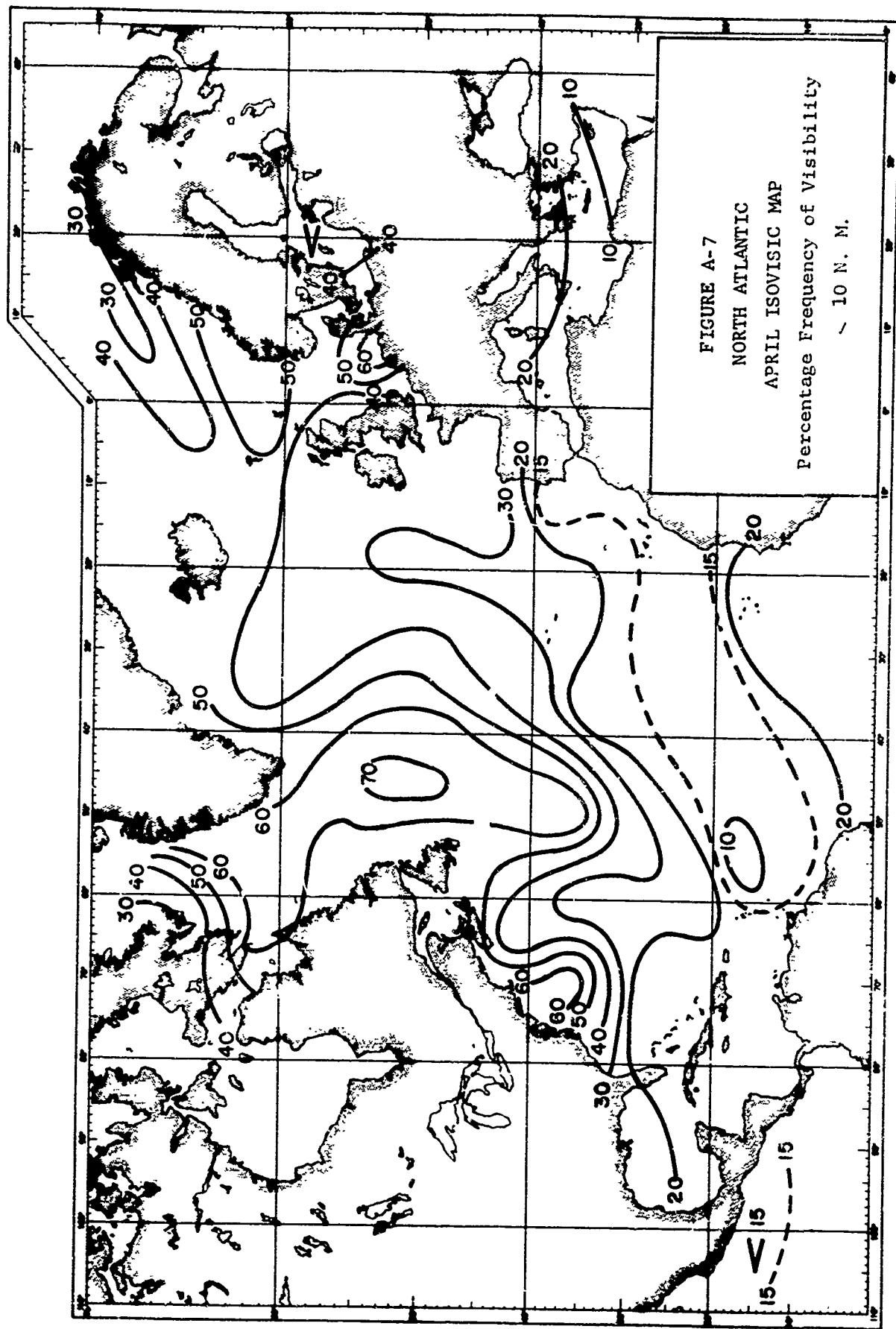


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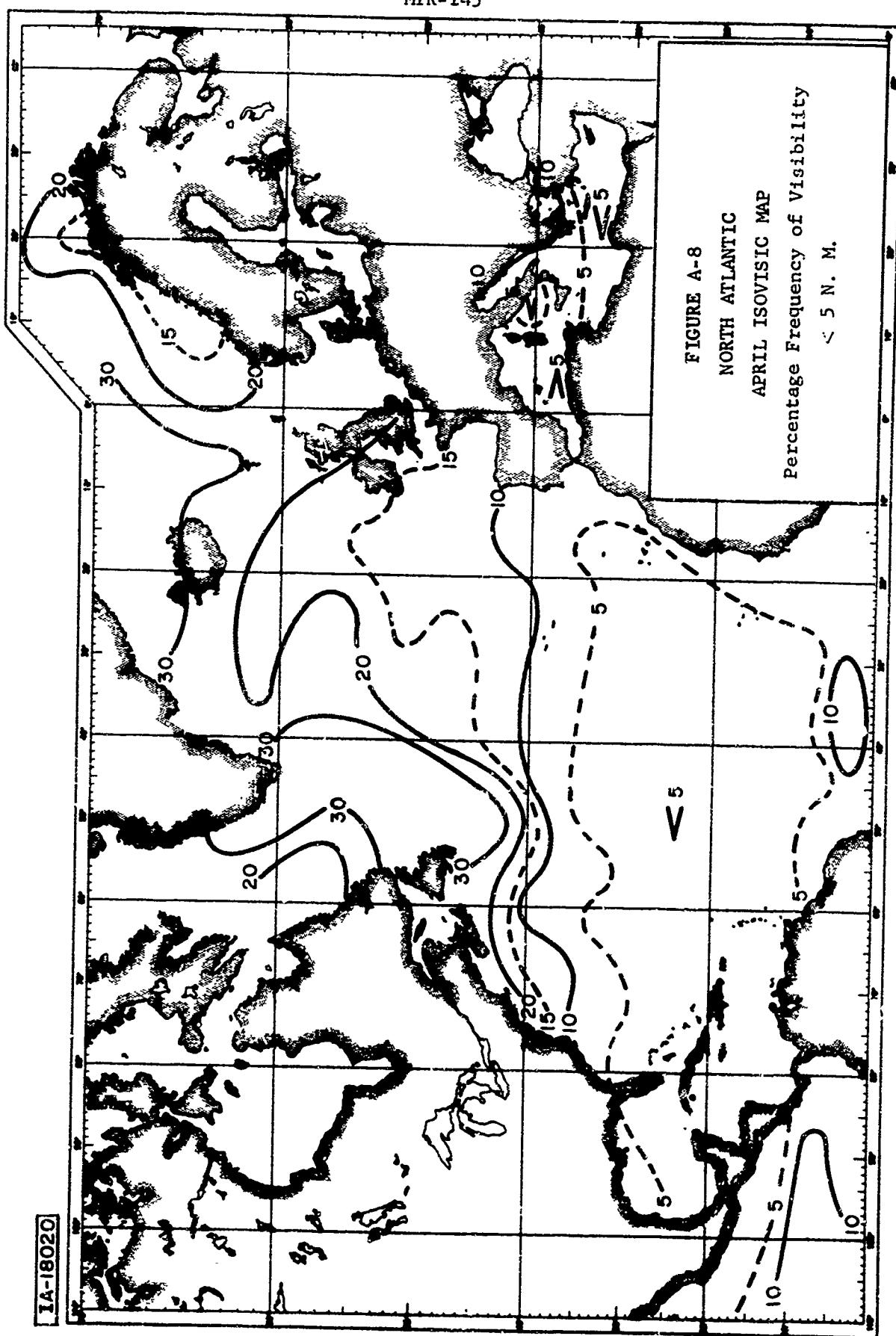


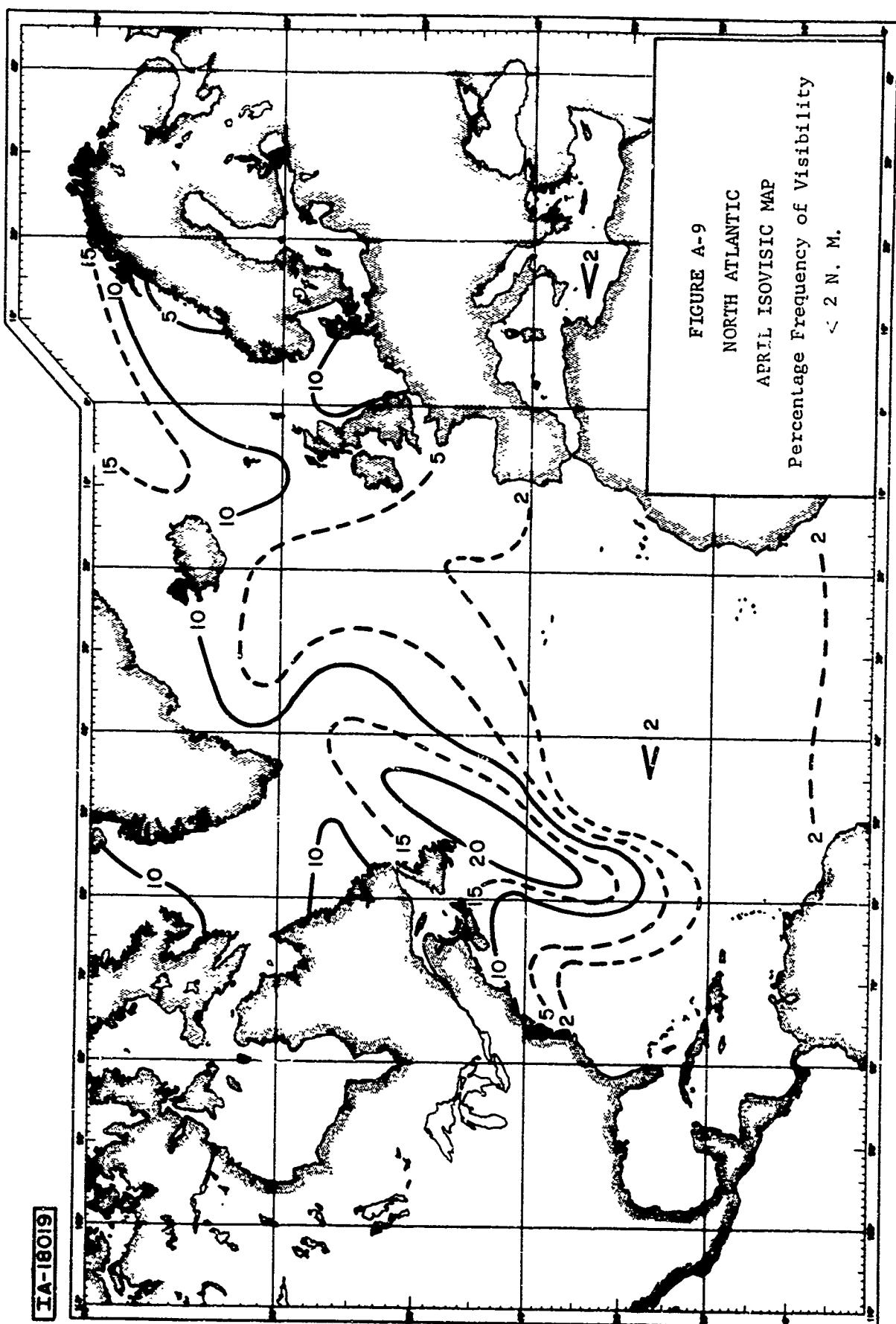
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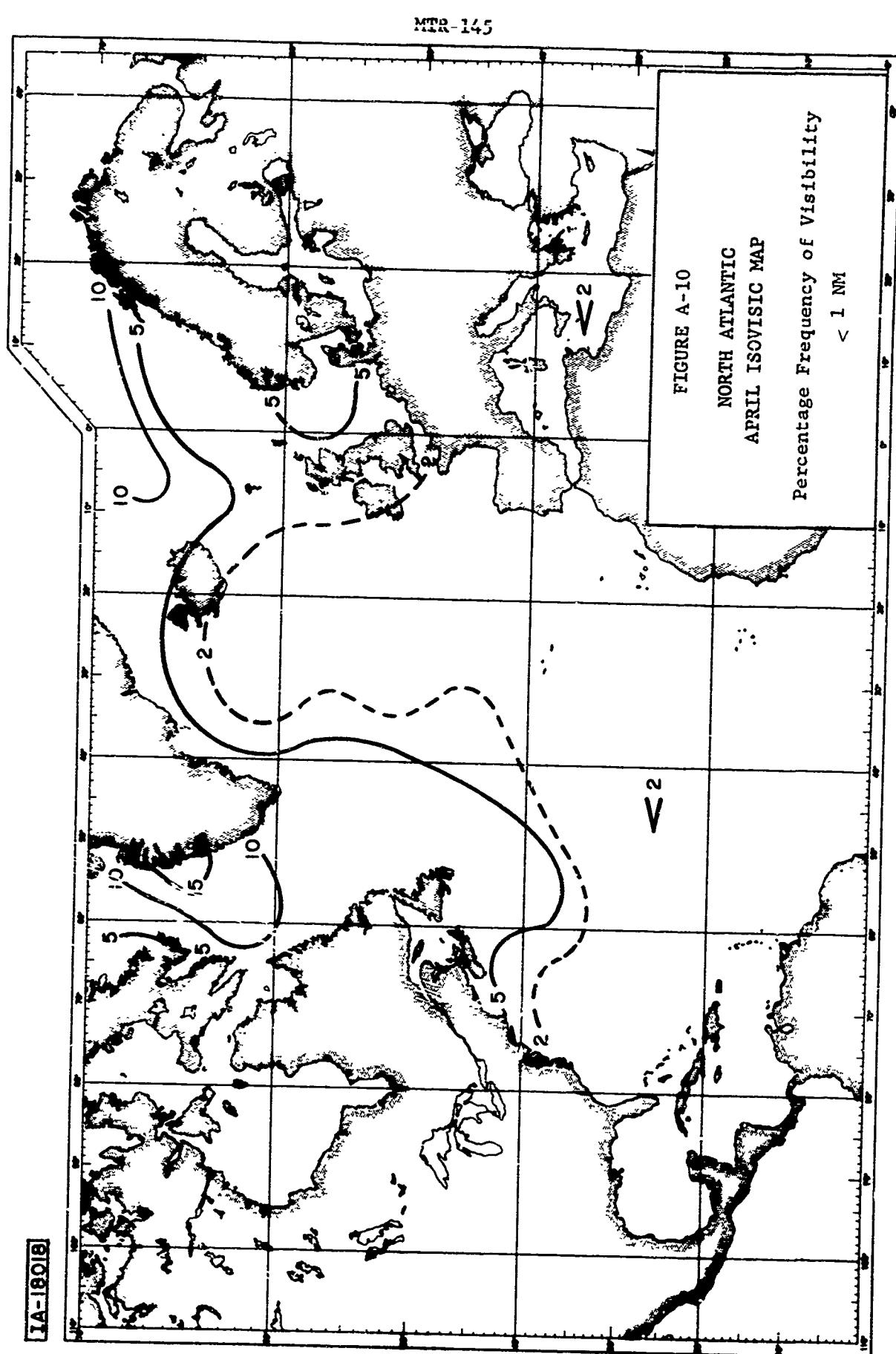
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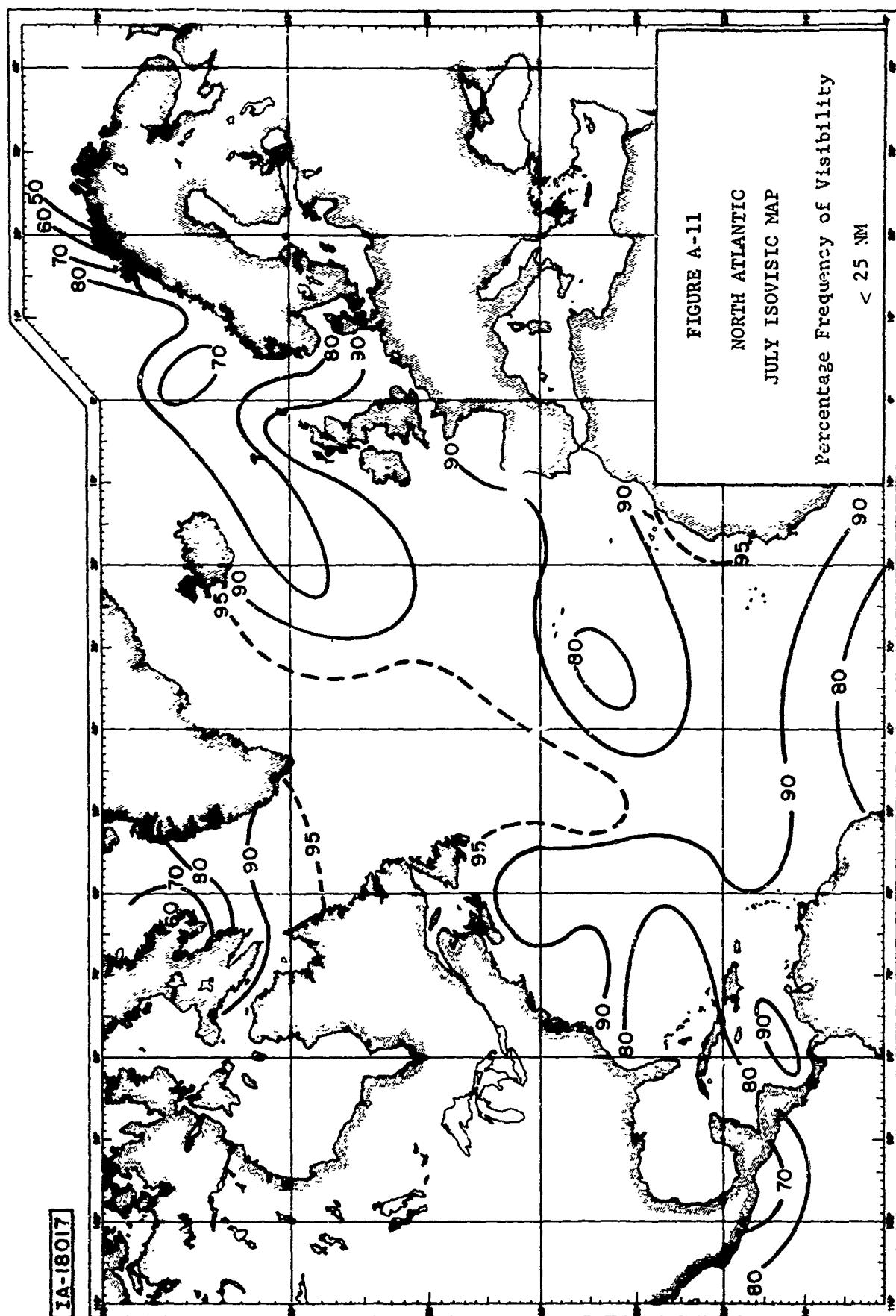
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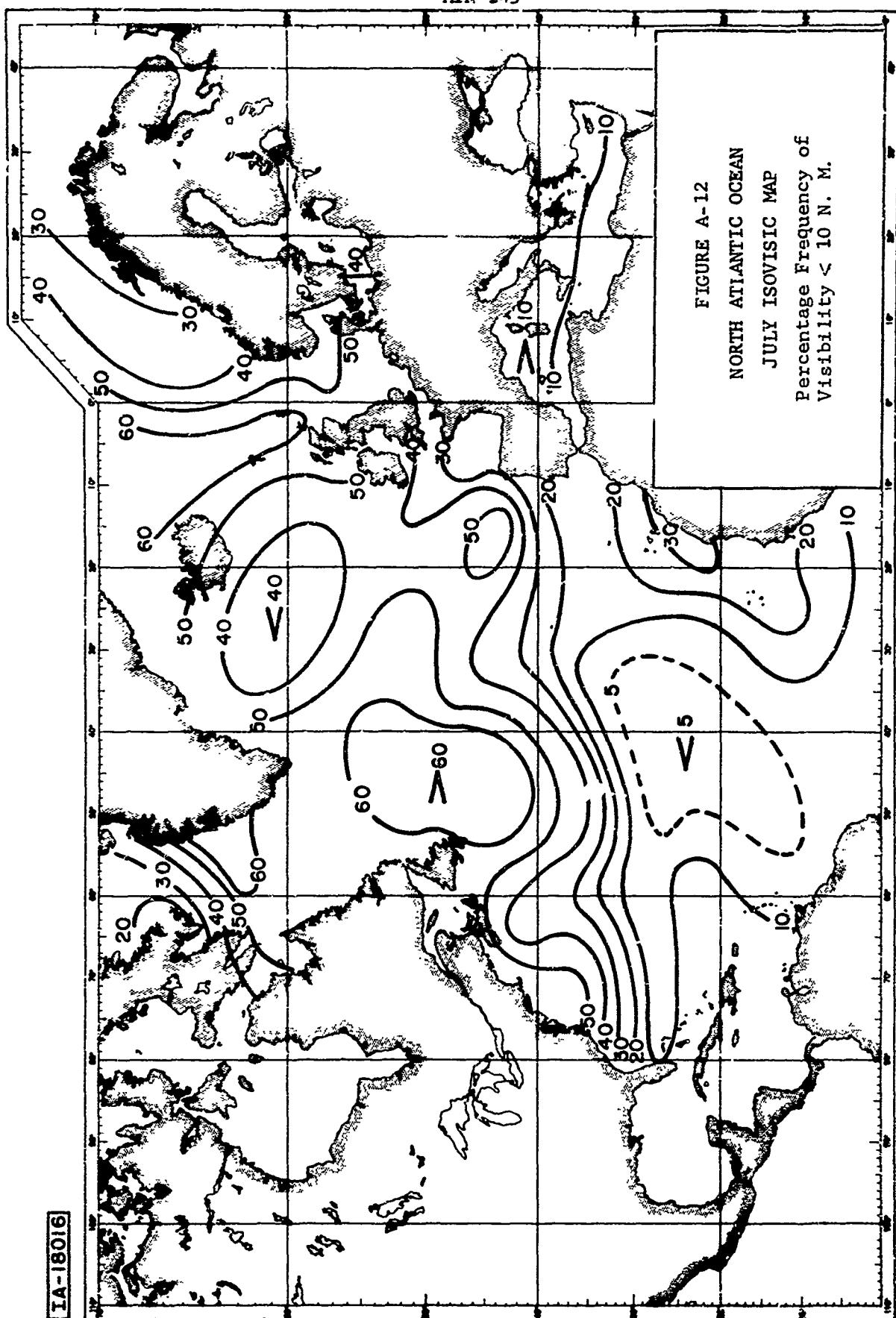


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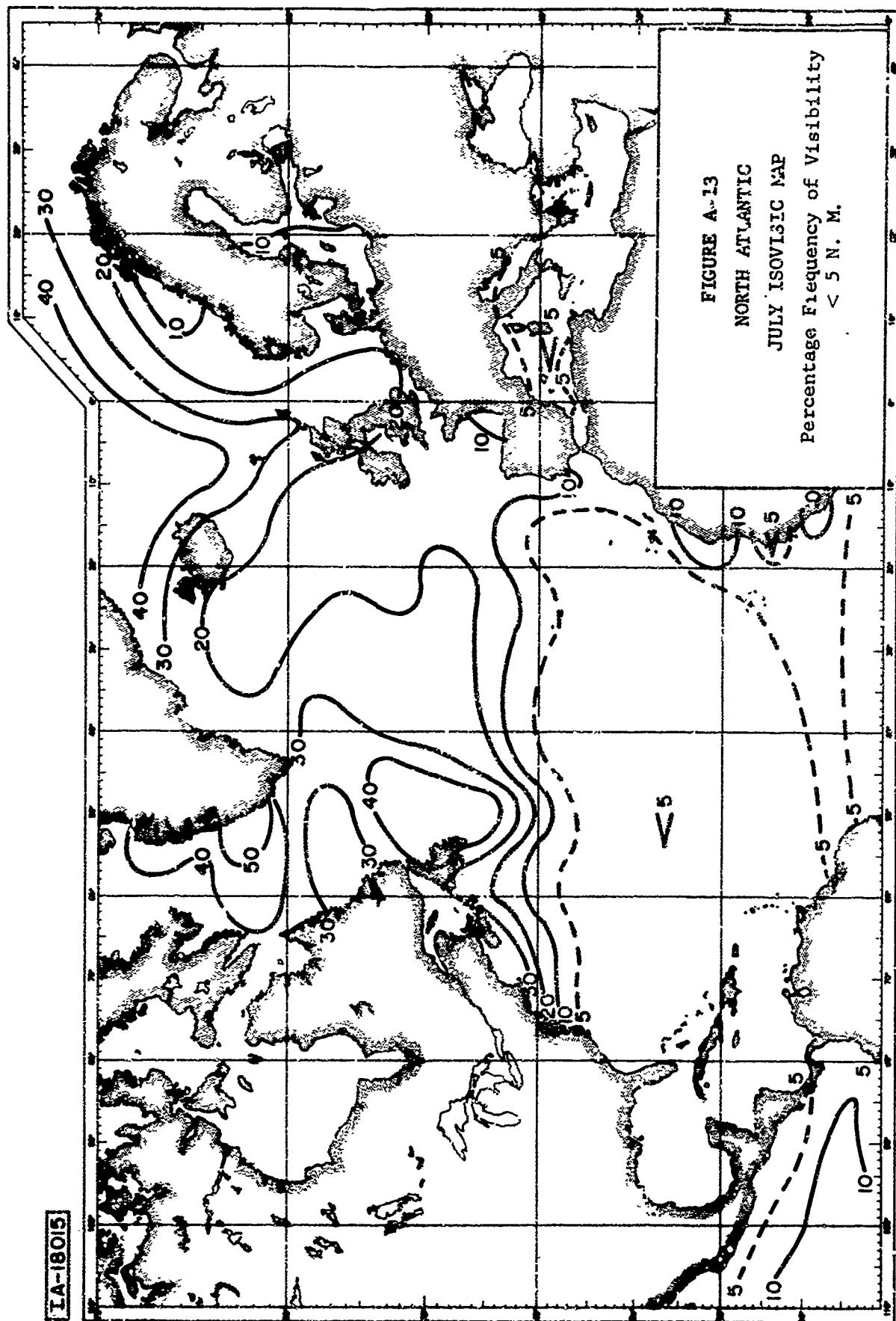




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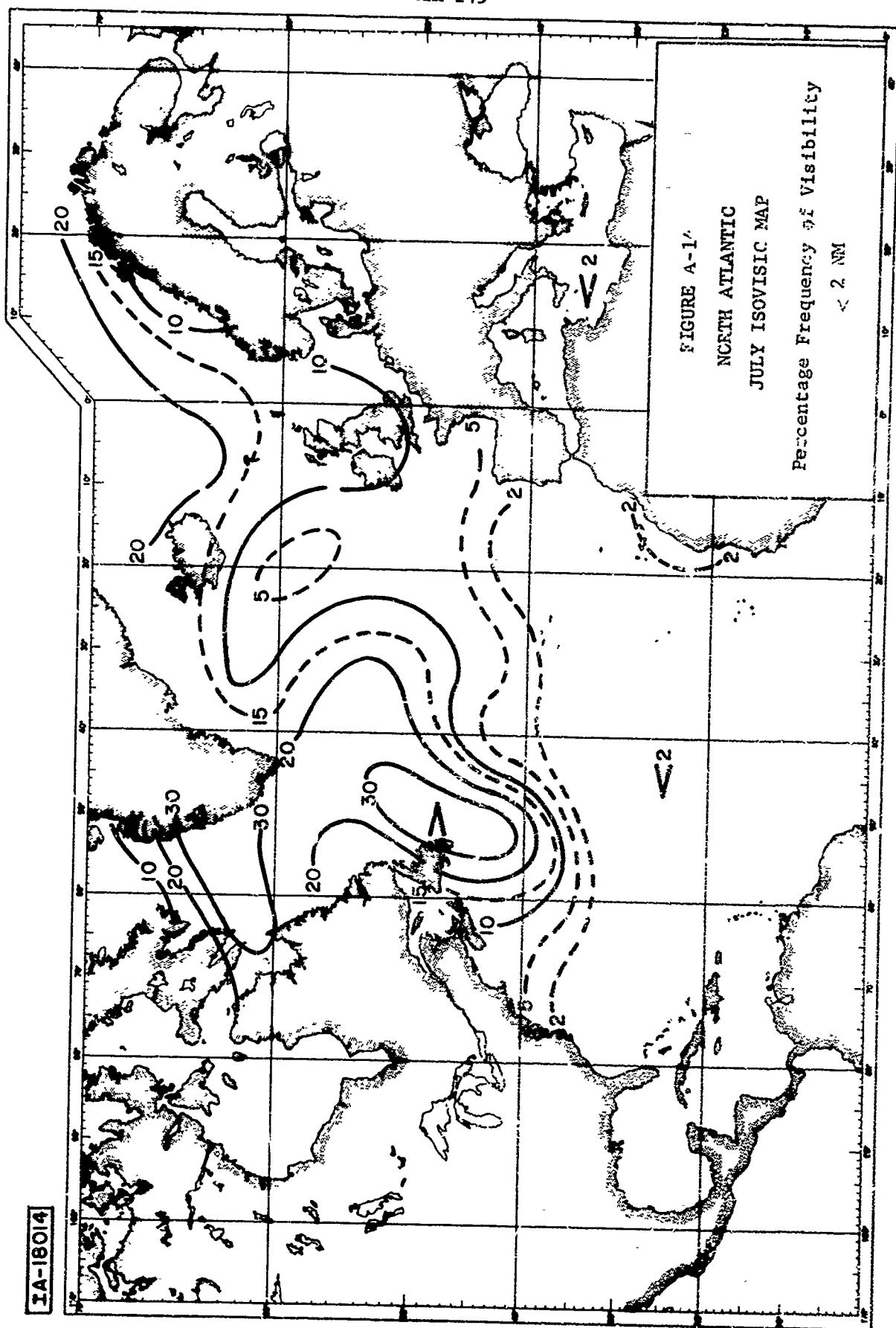


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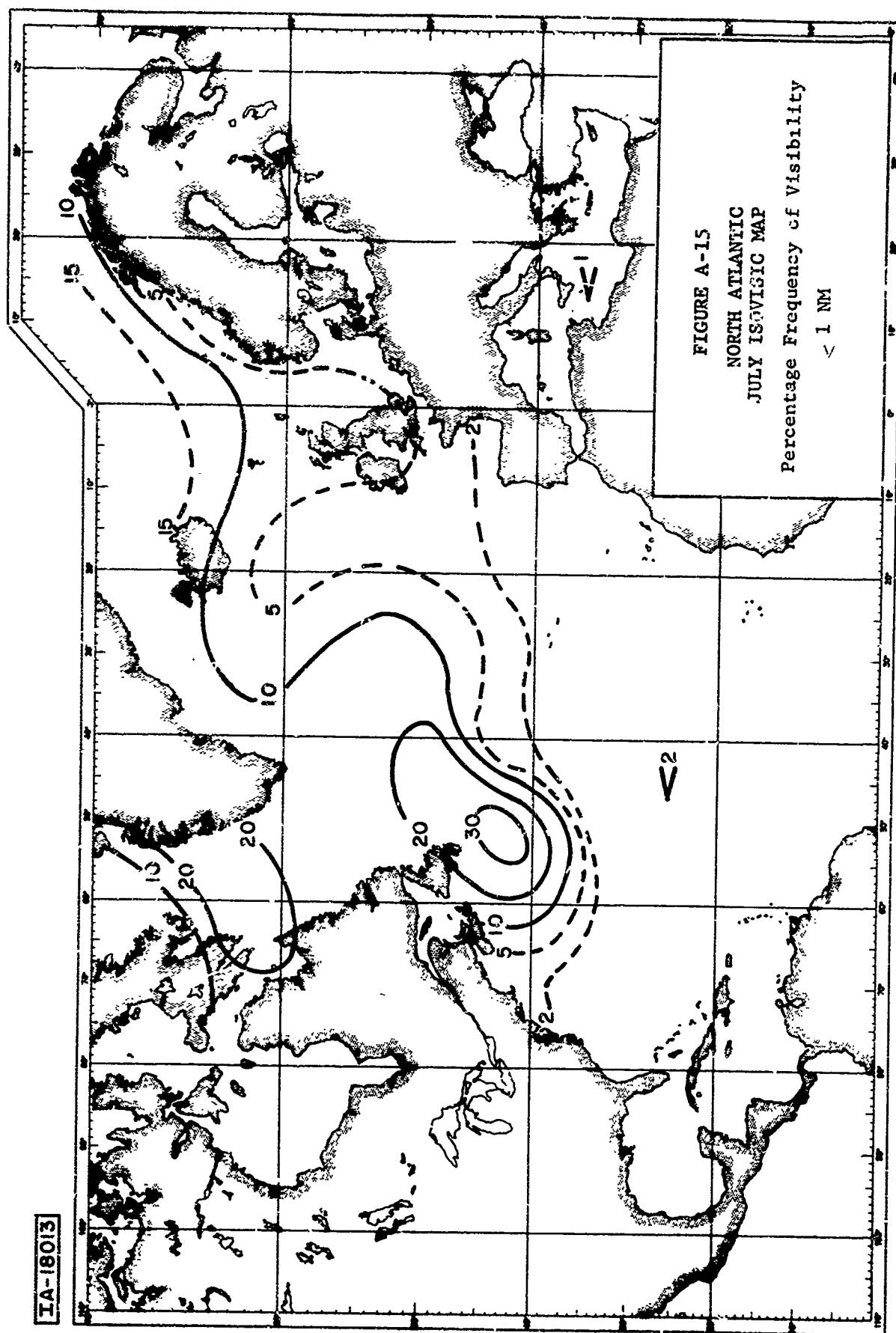


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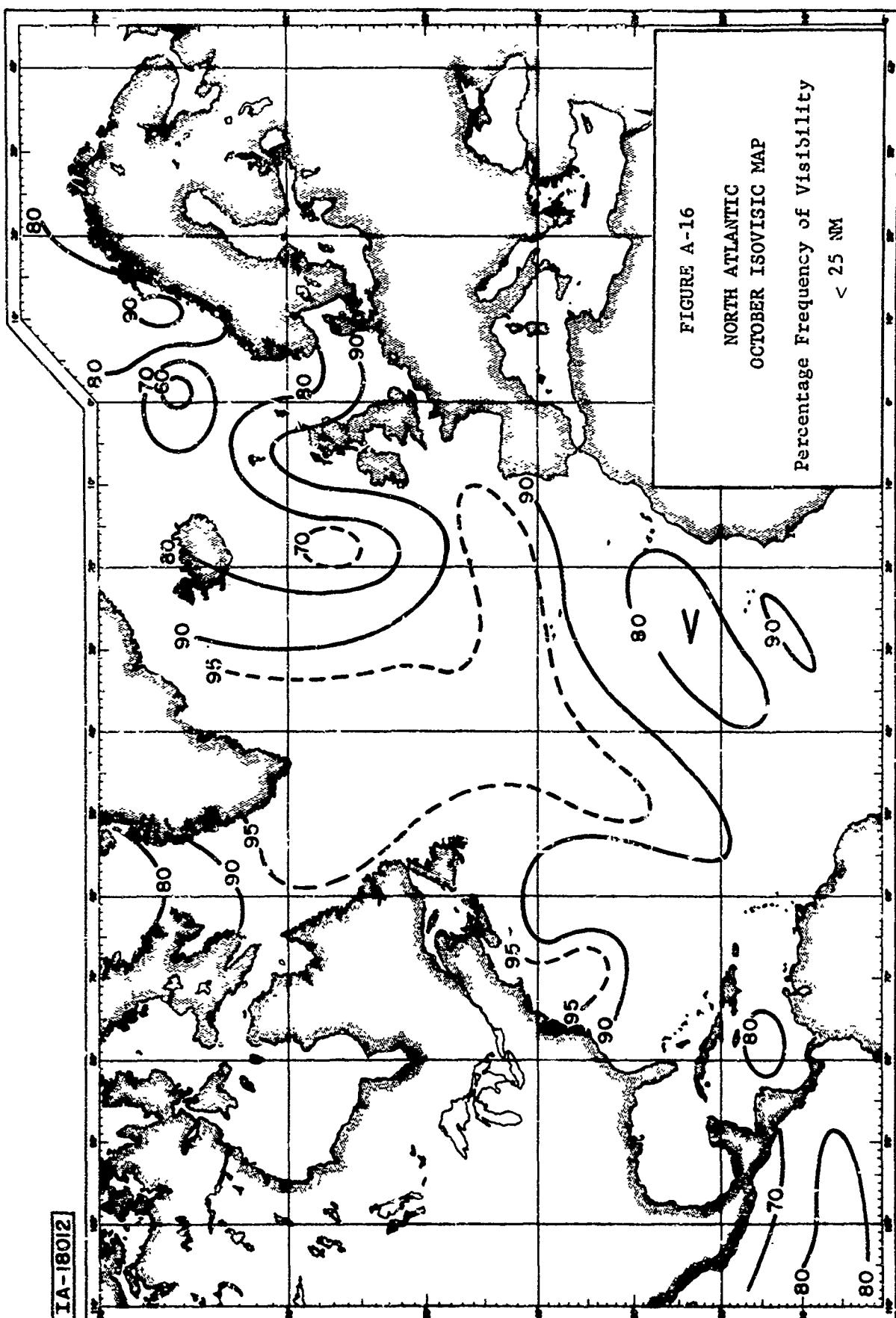
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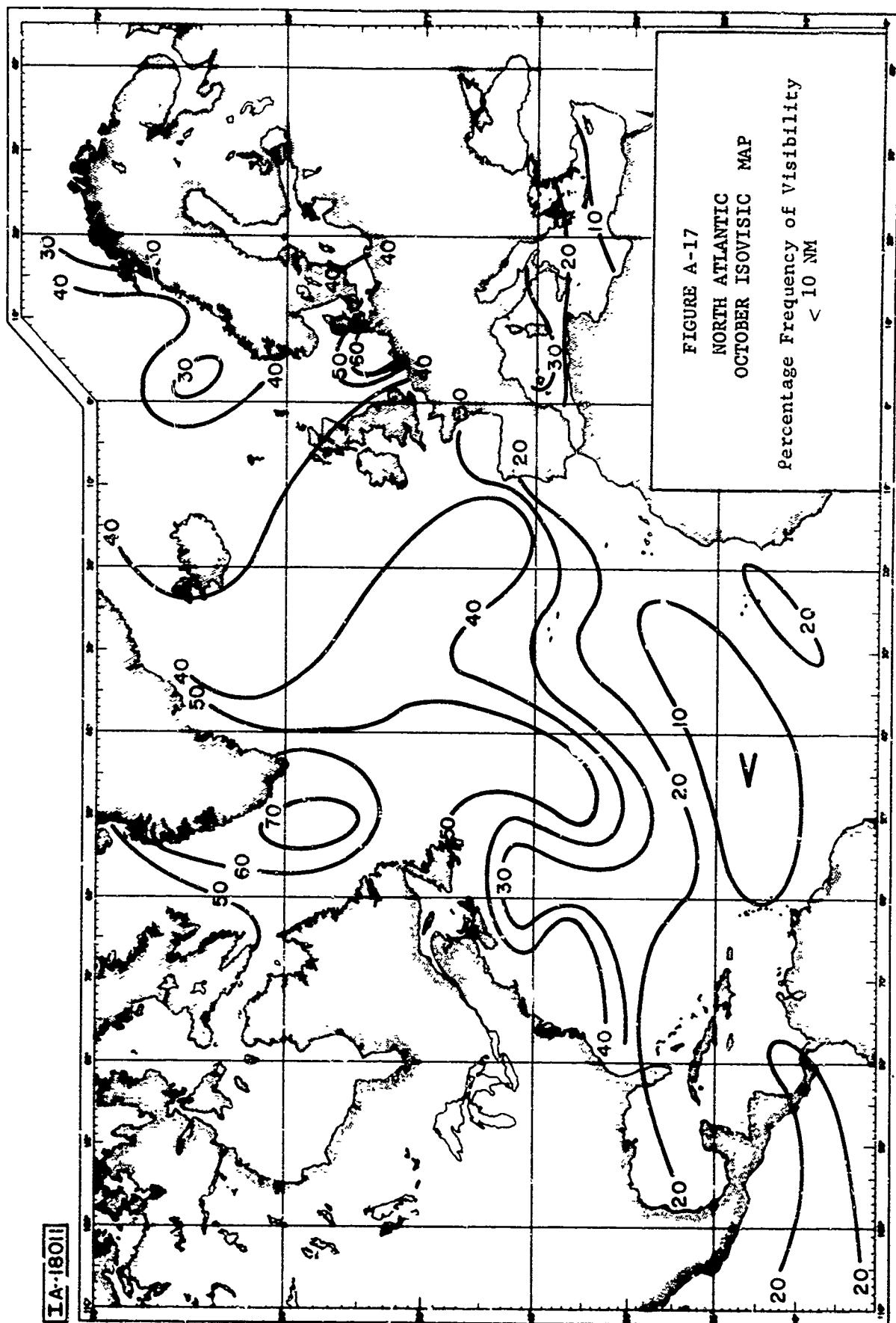


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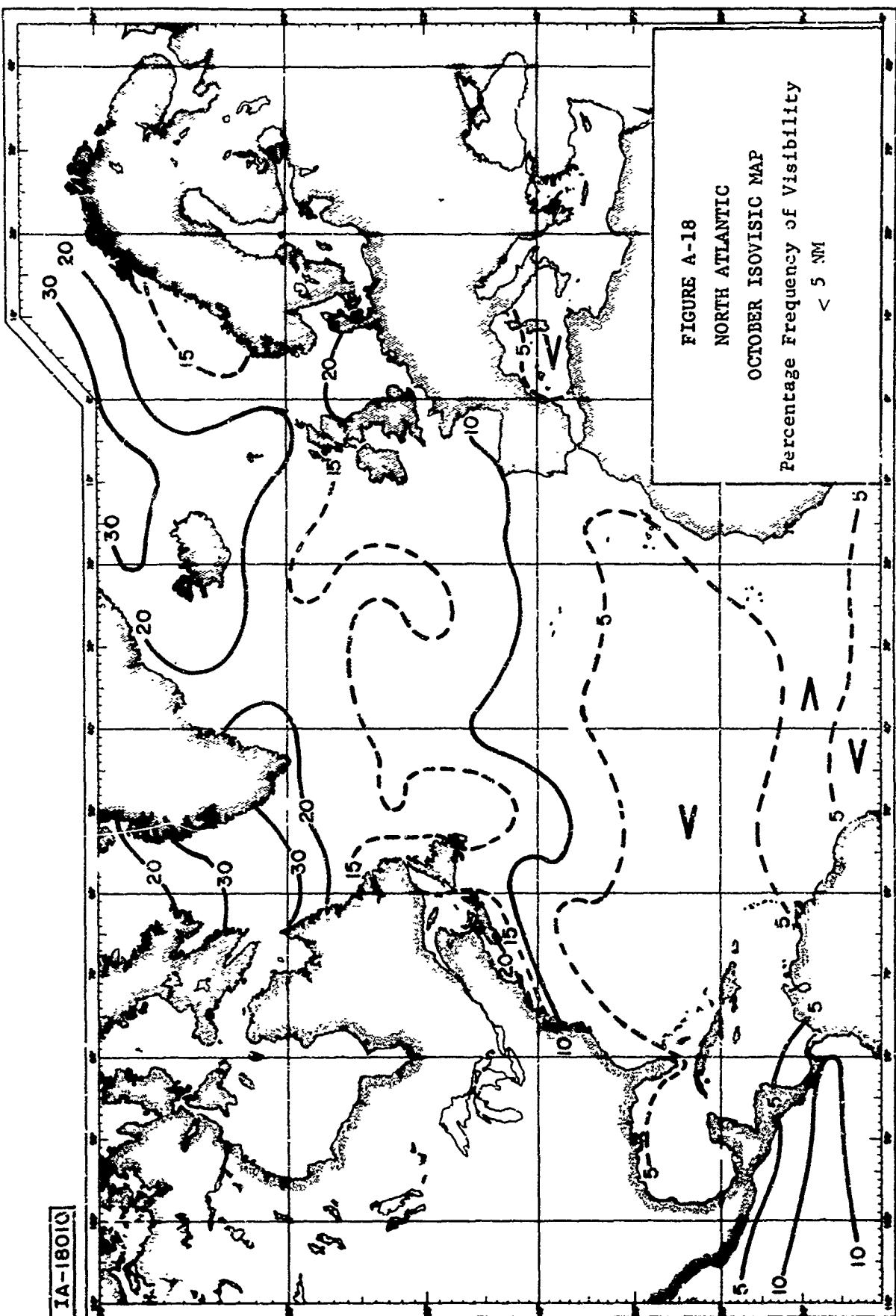


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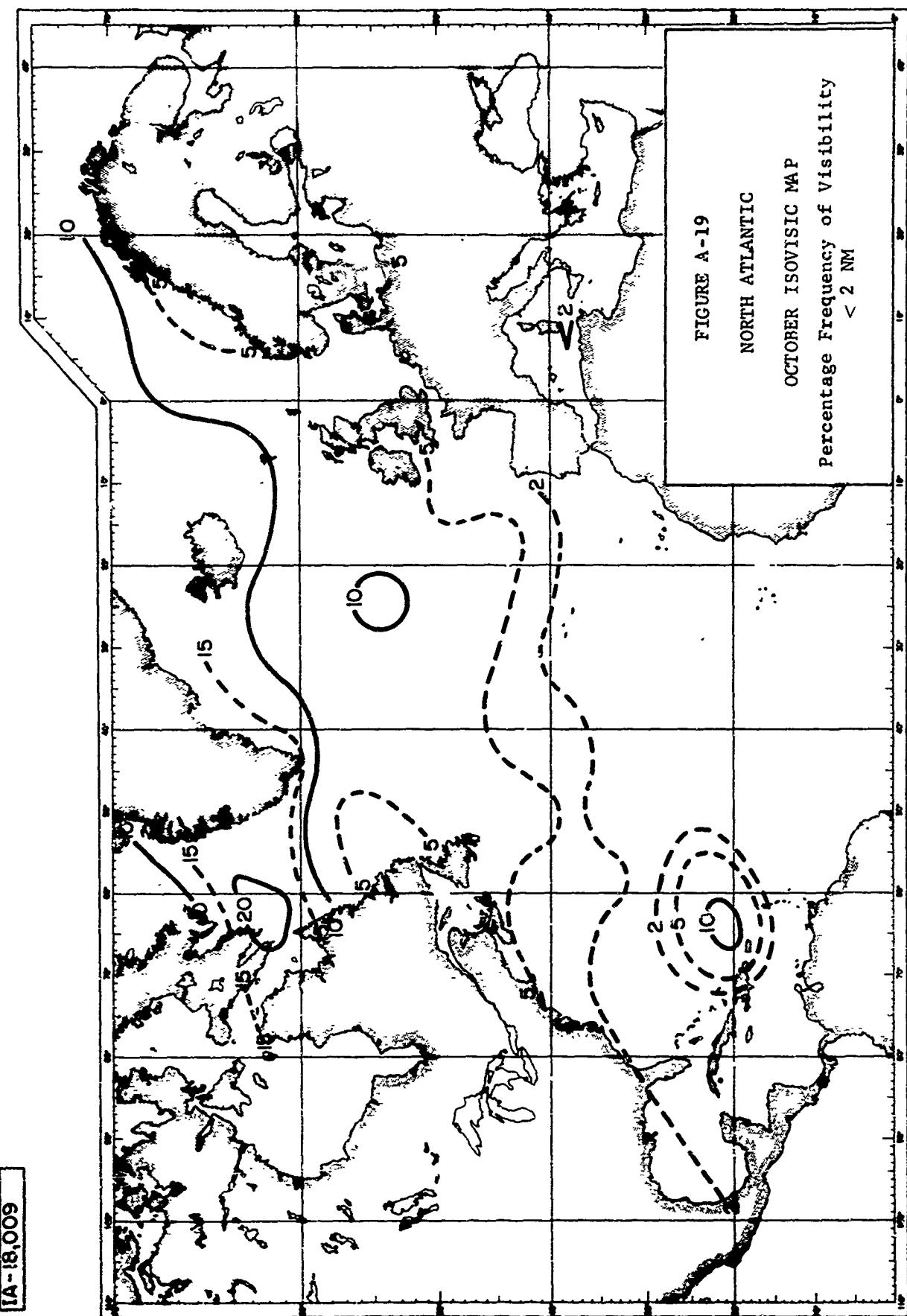


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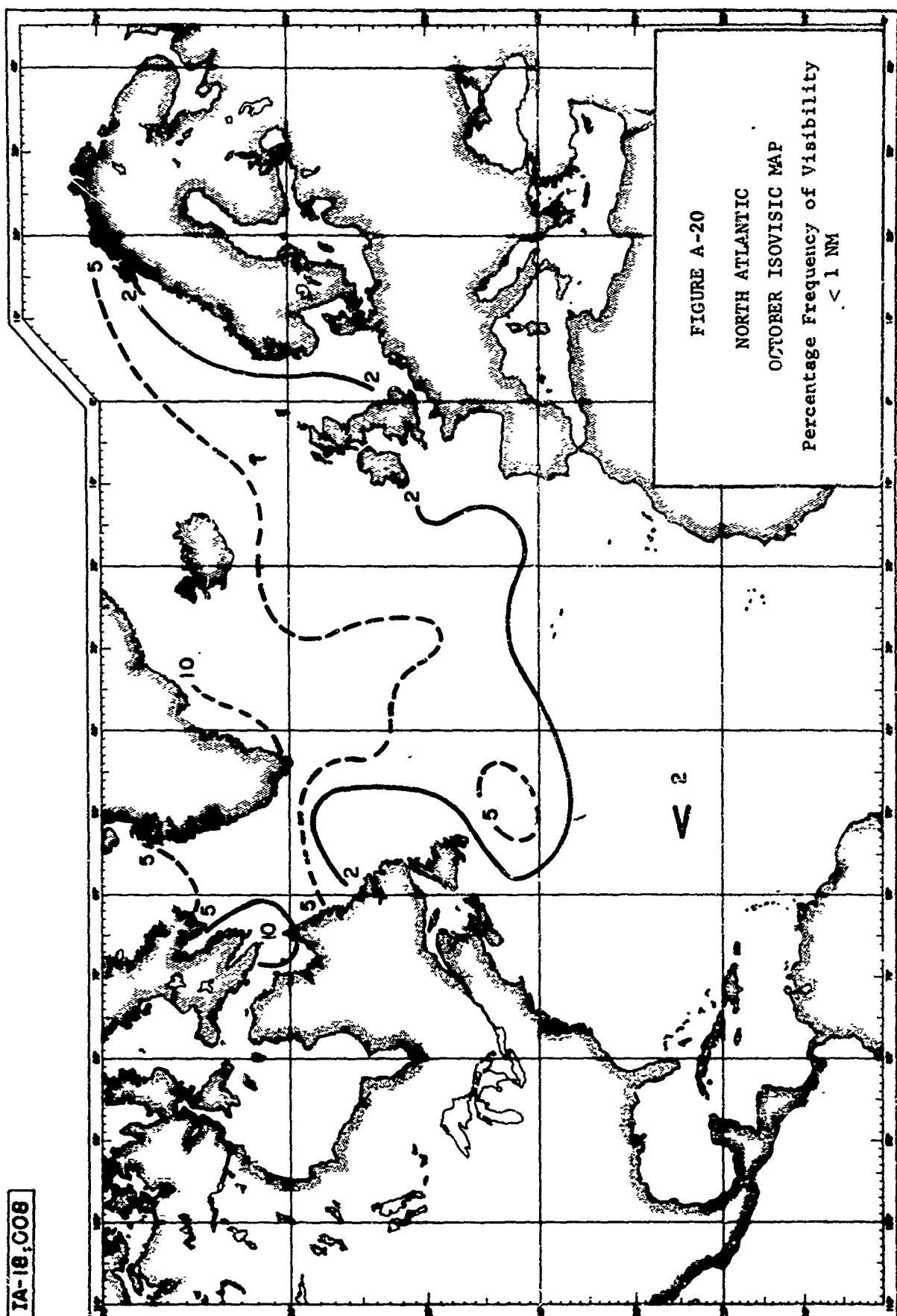
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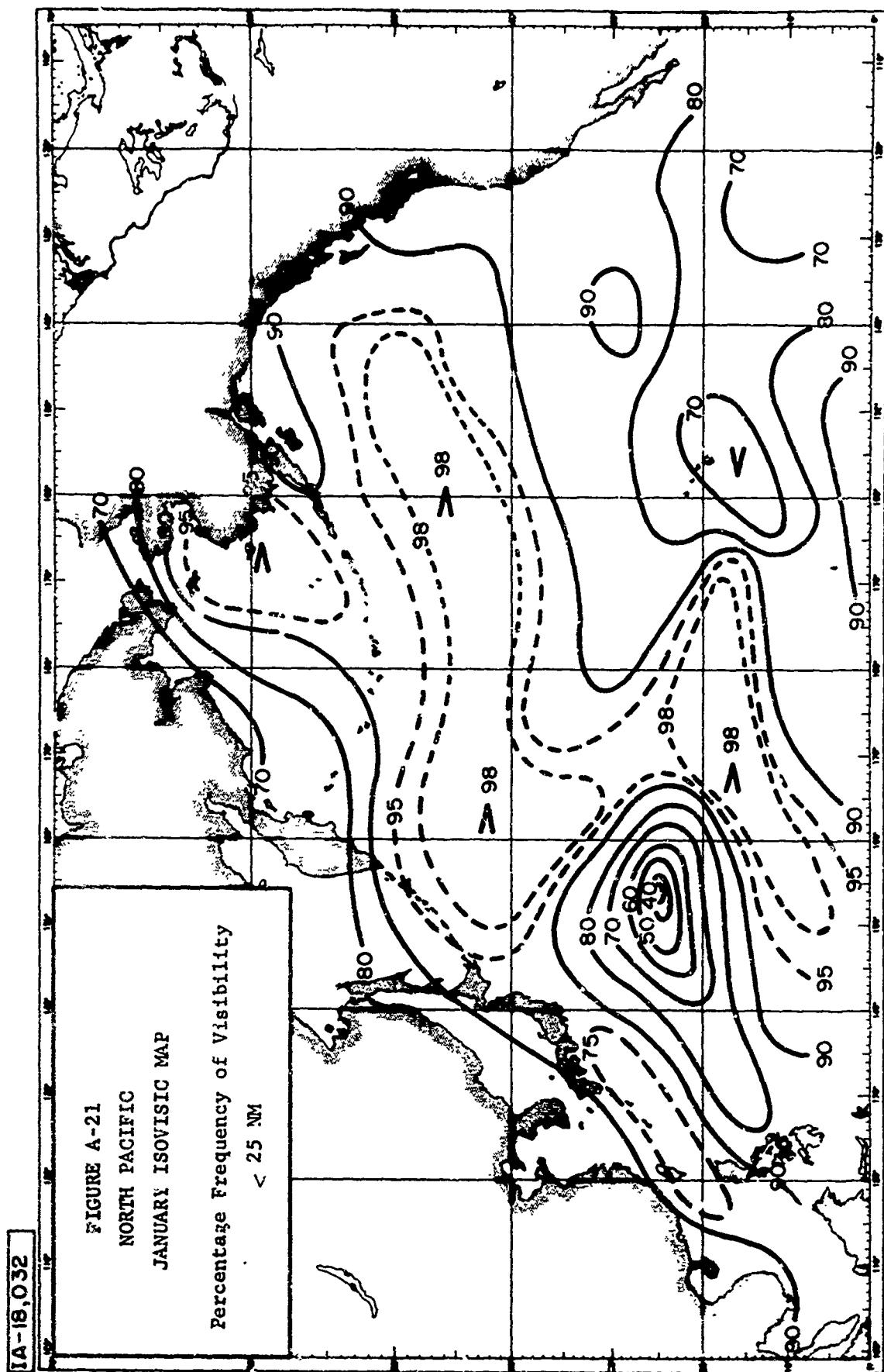
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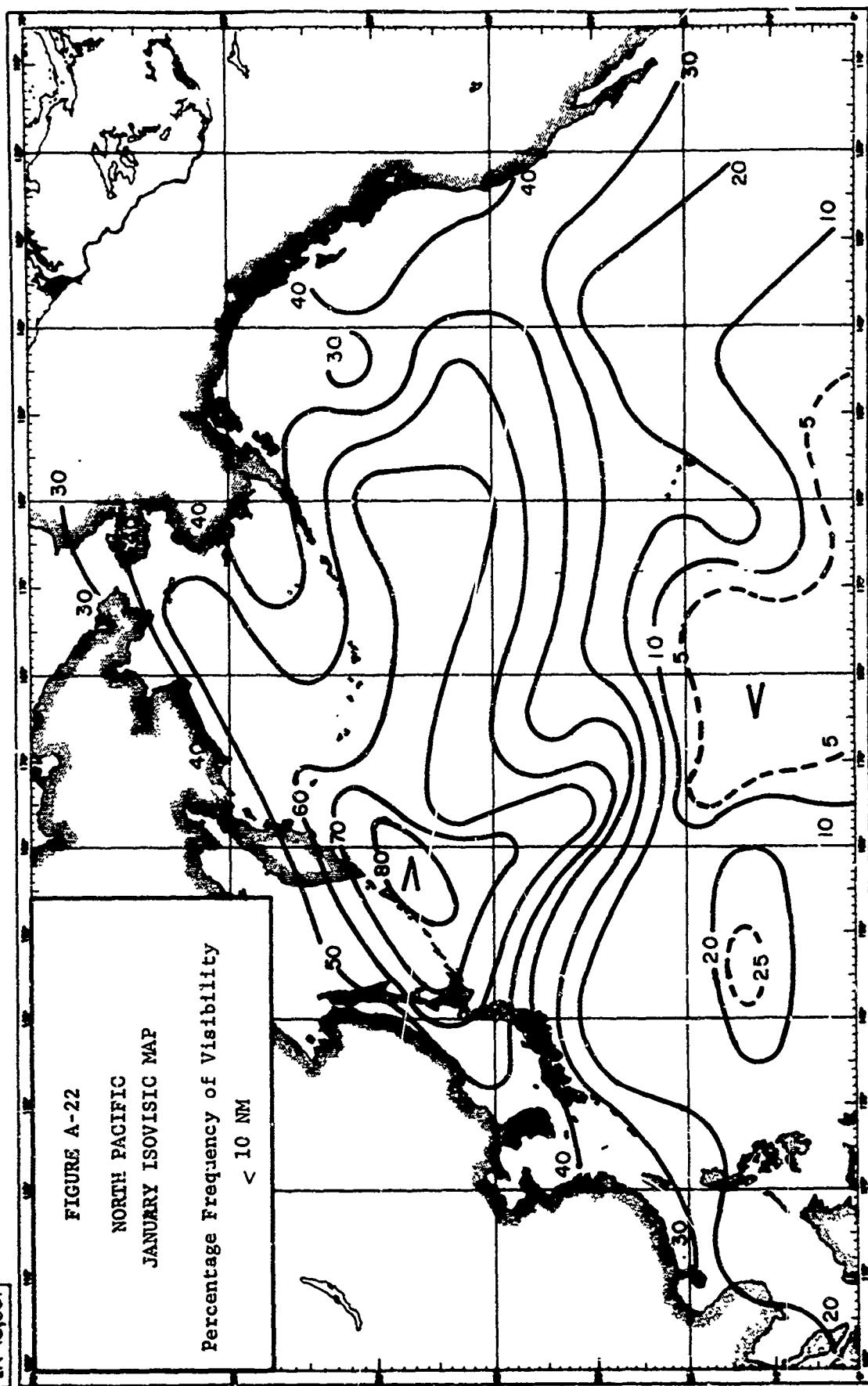
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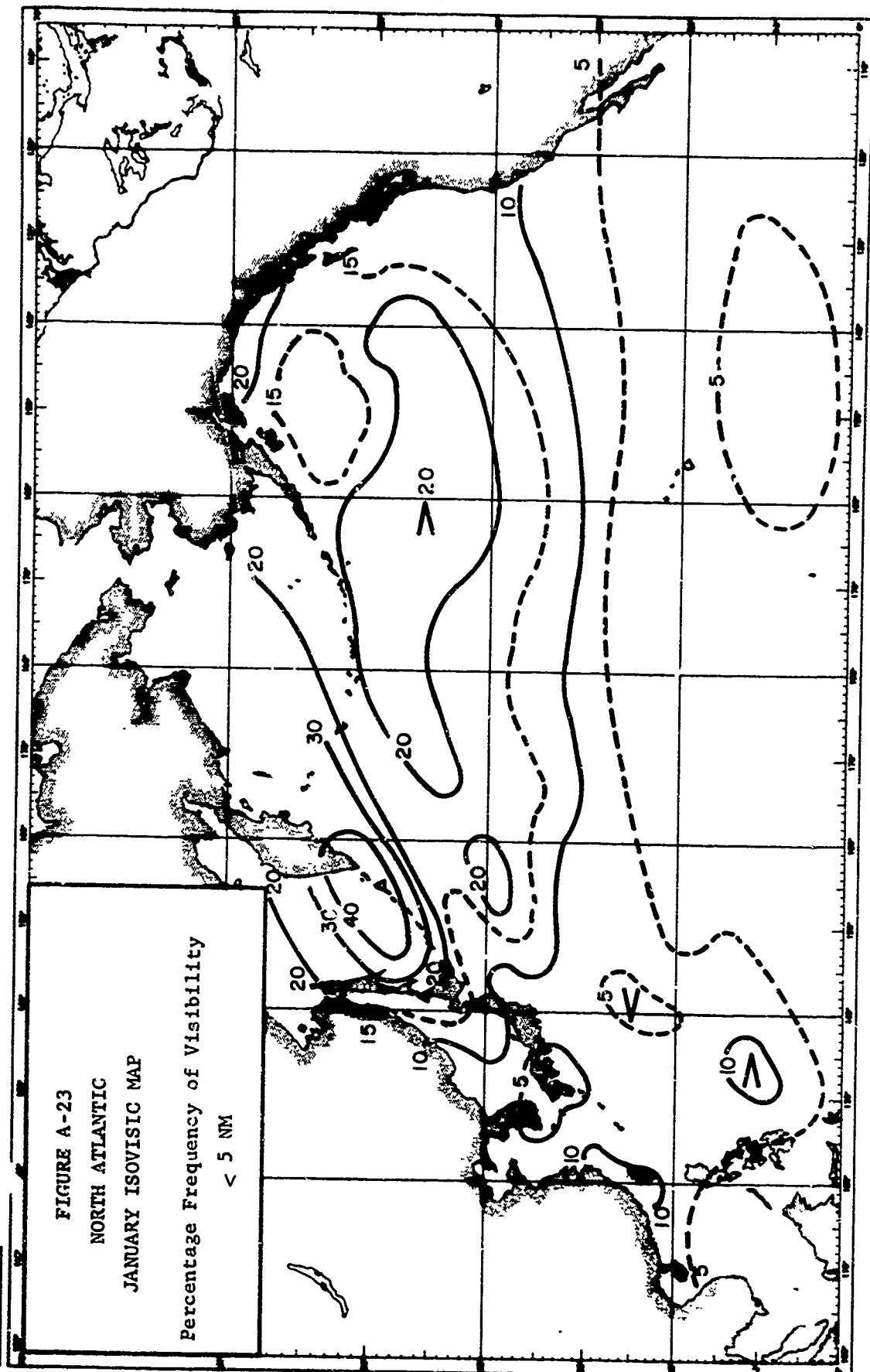
FIGURE A-23

NORTH ATLANTIC

JANUARY ISOVISTIC MAP

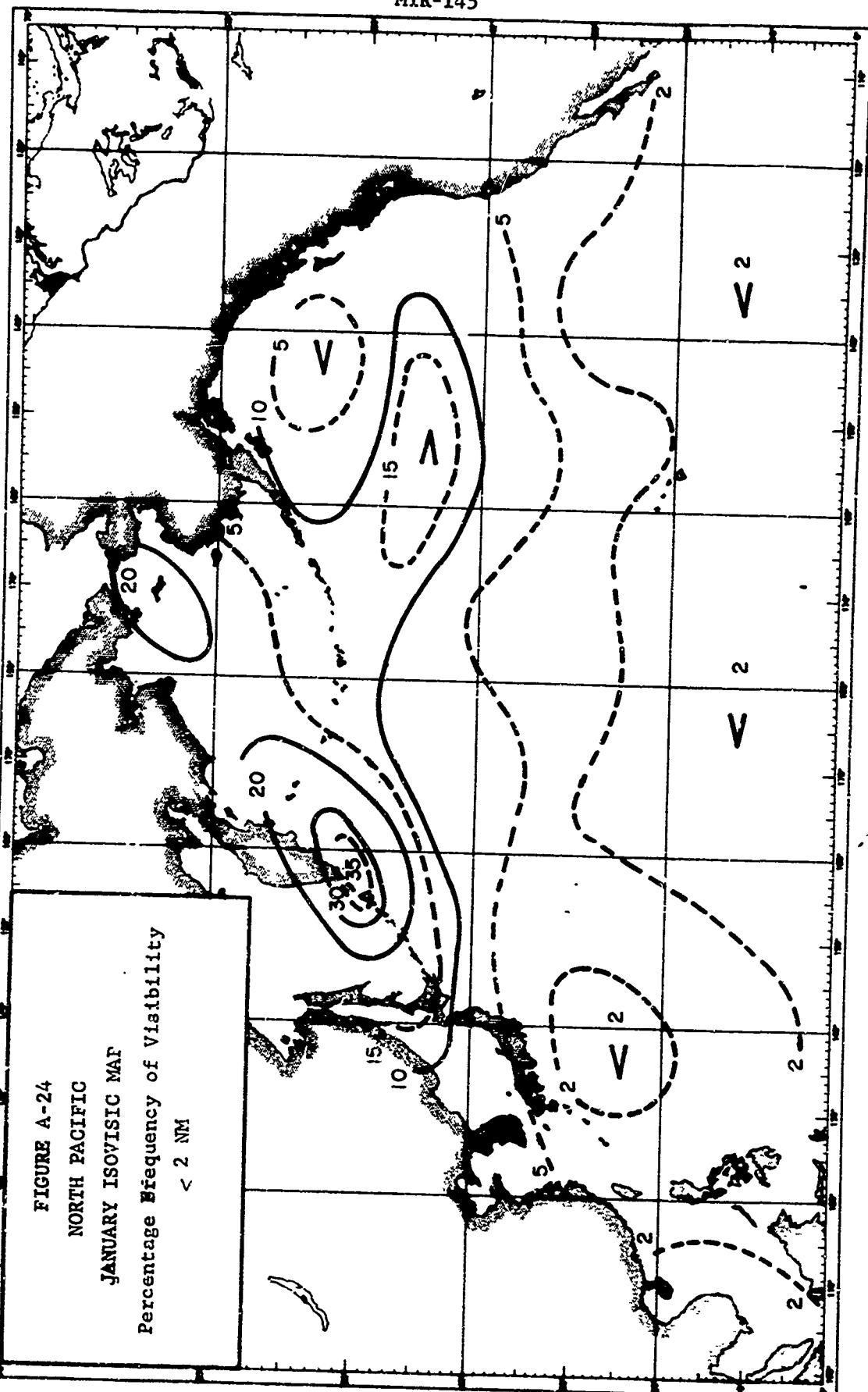
Percentage Frequency of Visibility
 $< 5 \text{ NM}$

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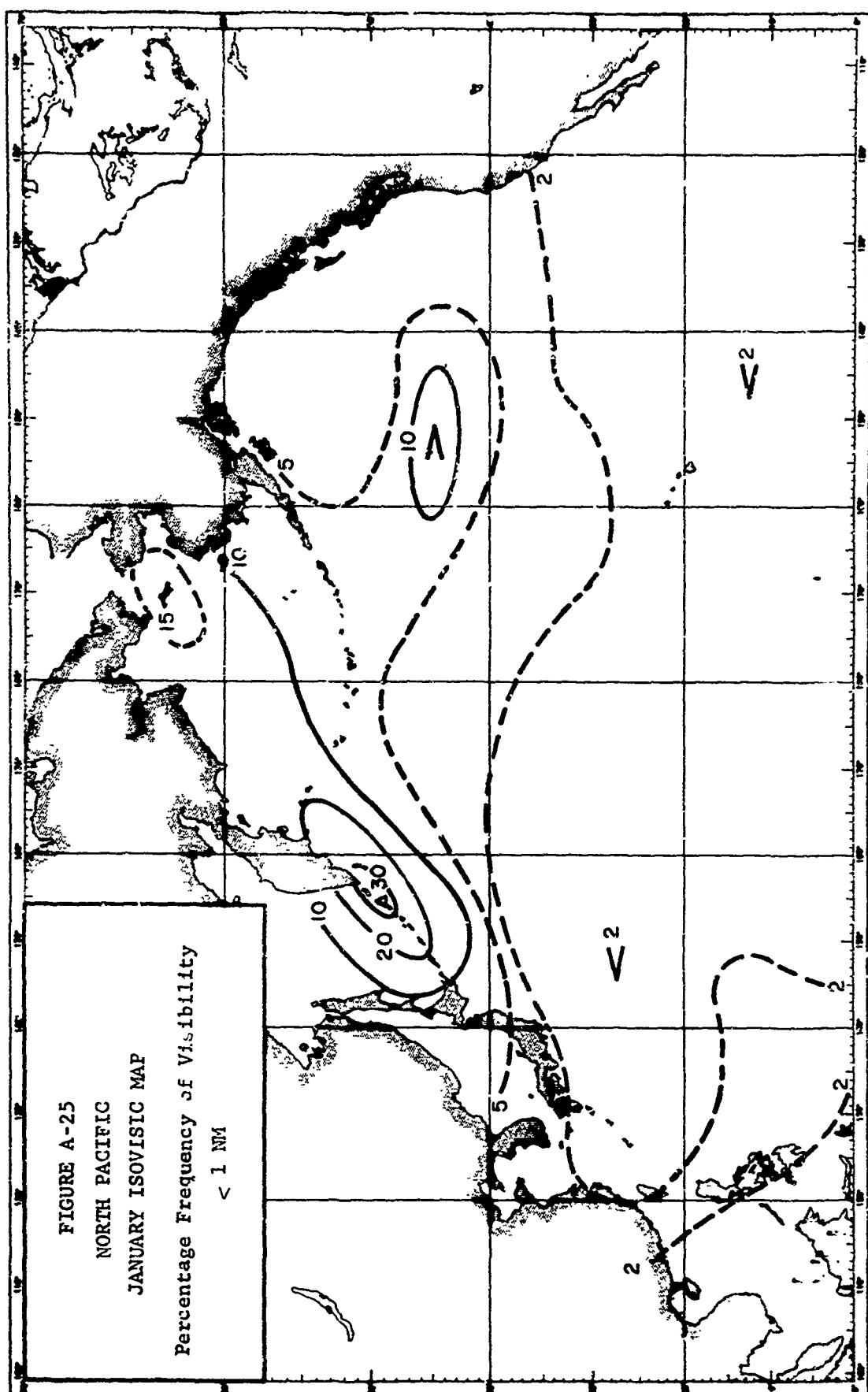


IA-18,029

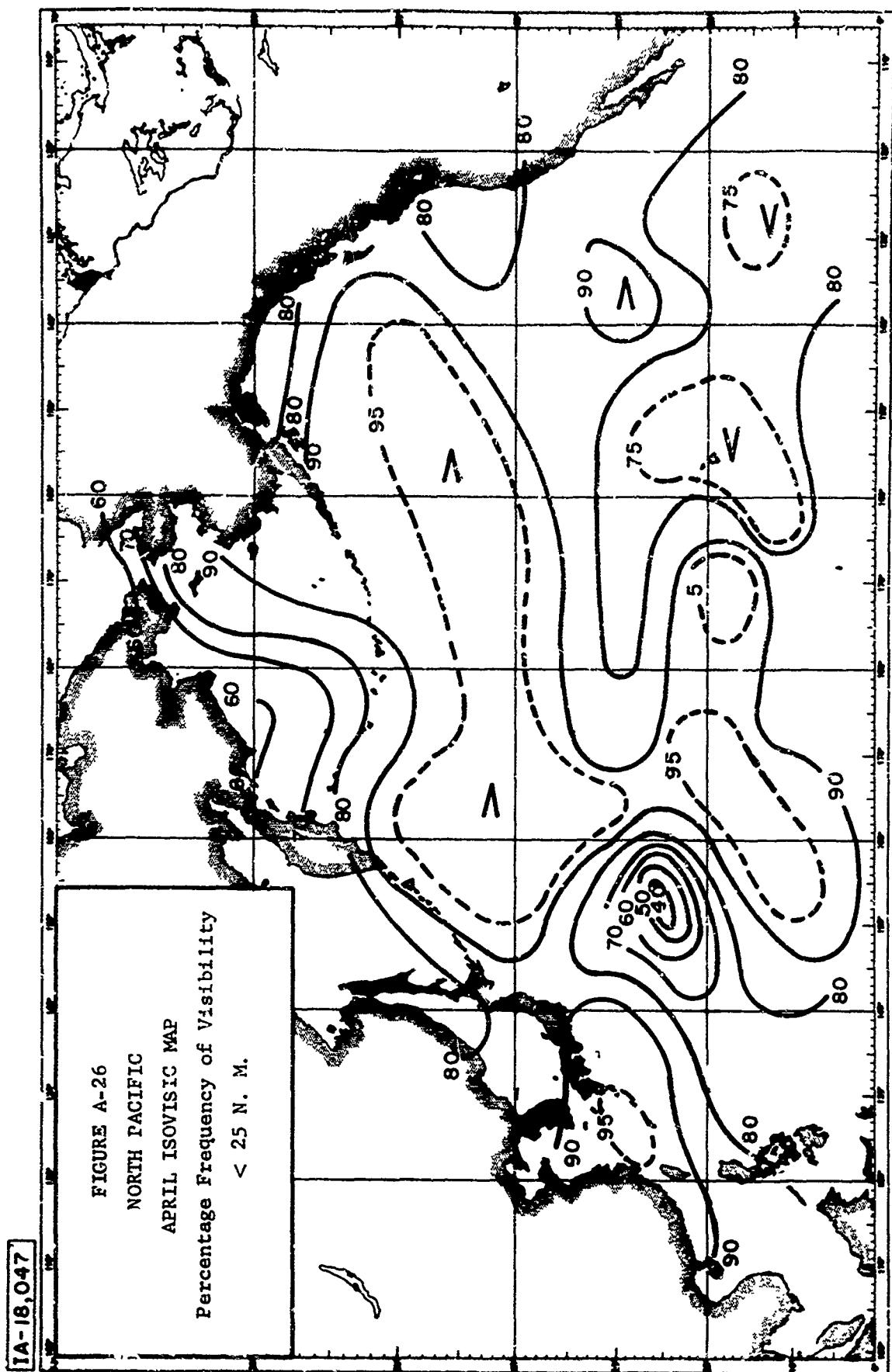
FIGURE A-24
NORTH PACIFIC
JANUARY ISOWVISIC MAP
Percentage Frequency of Visibility
< 2 NM



MTR-145

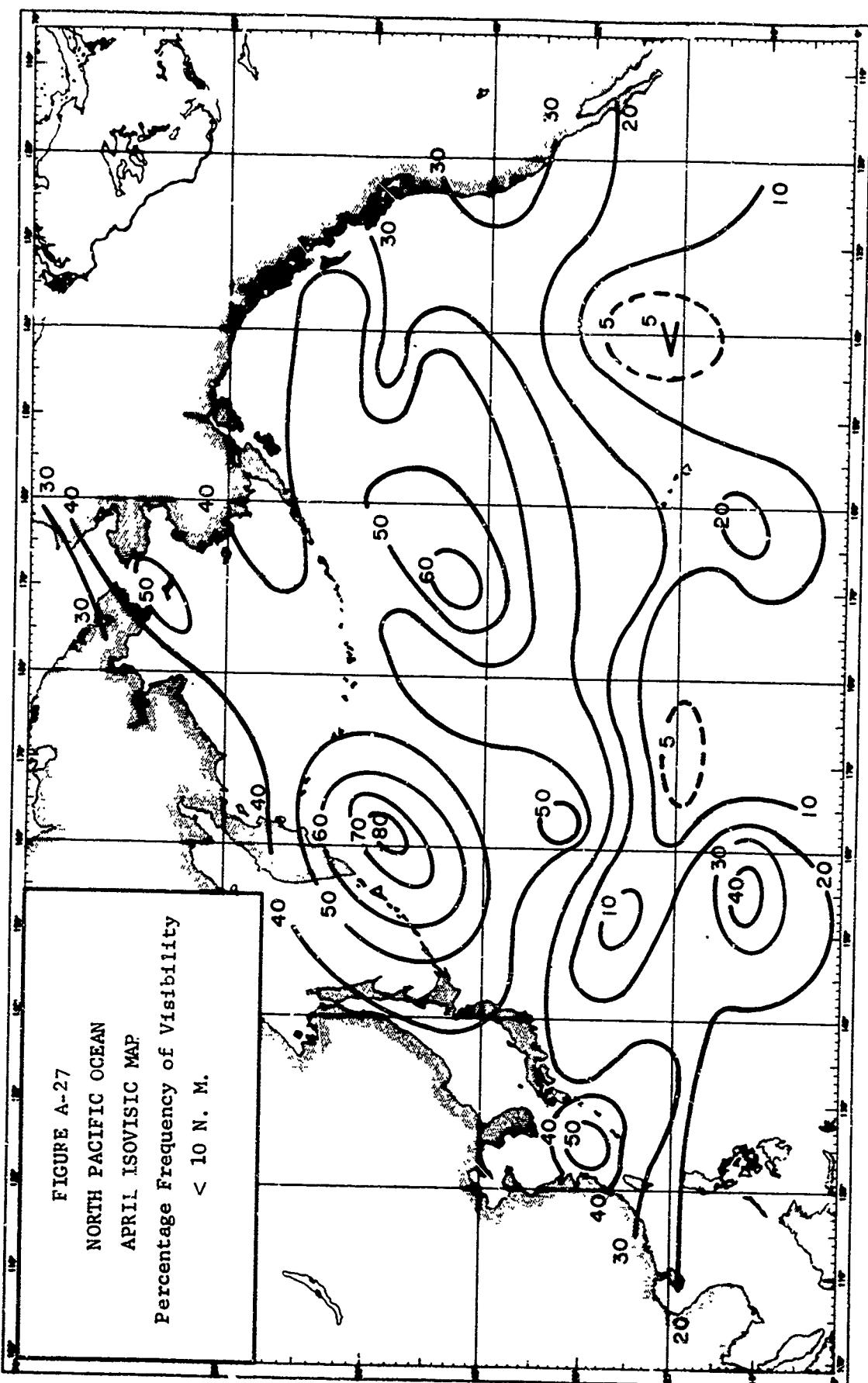


MTR-145

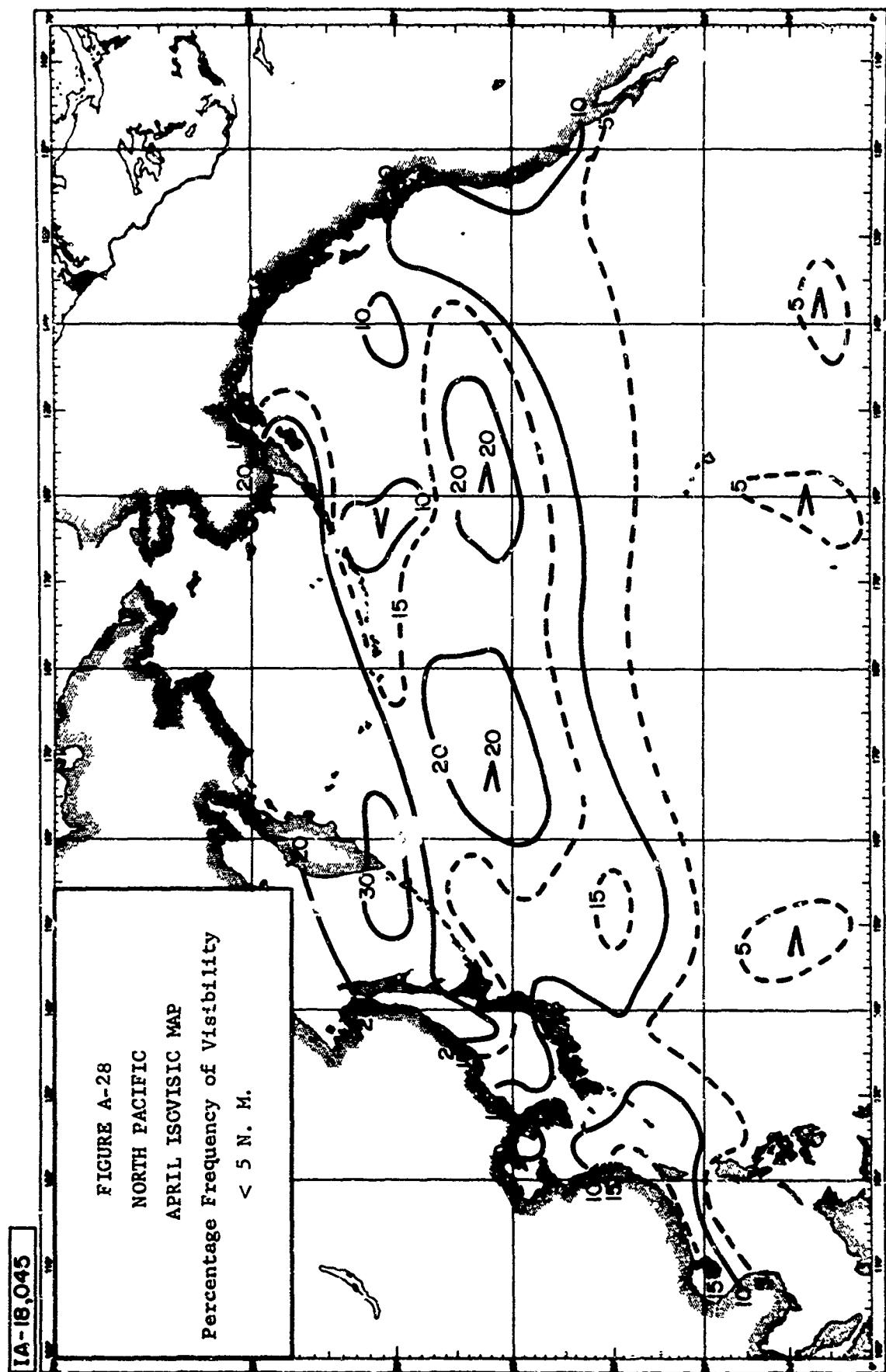


IA-18,046

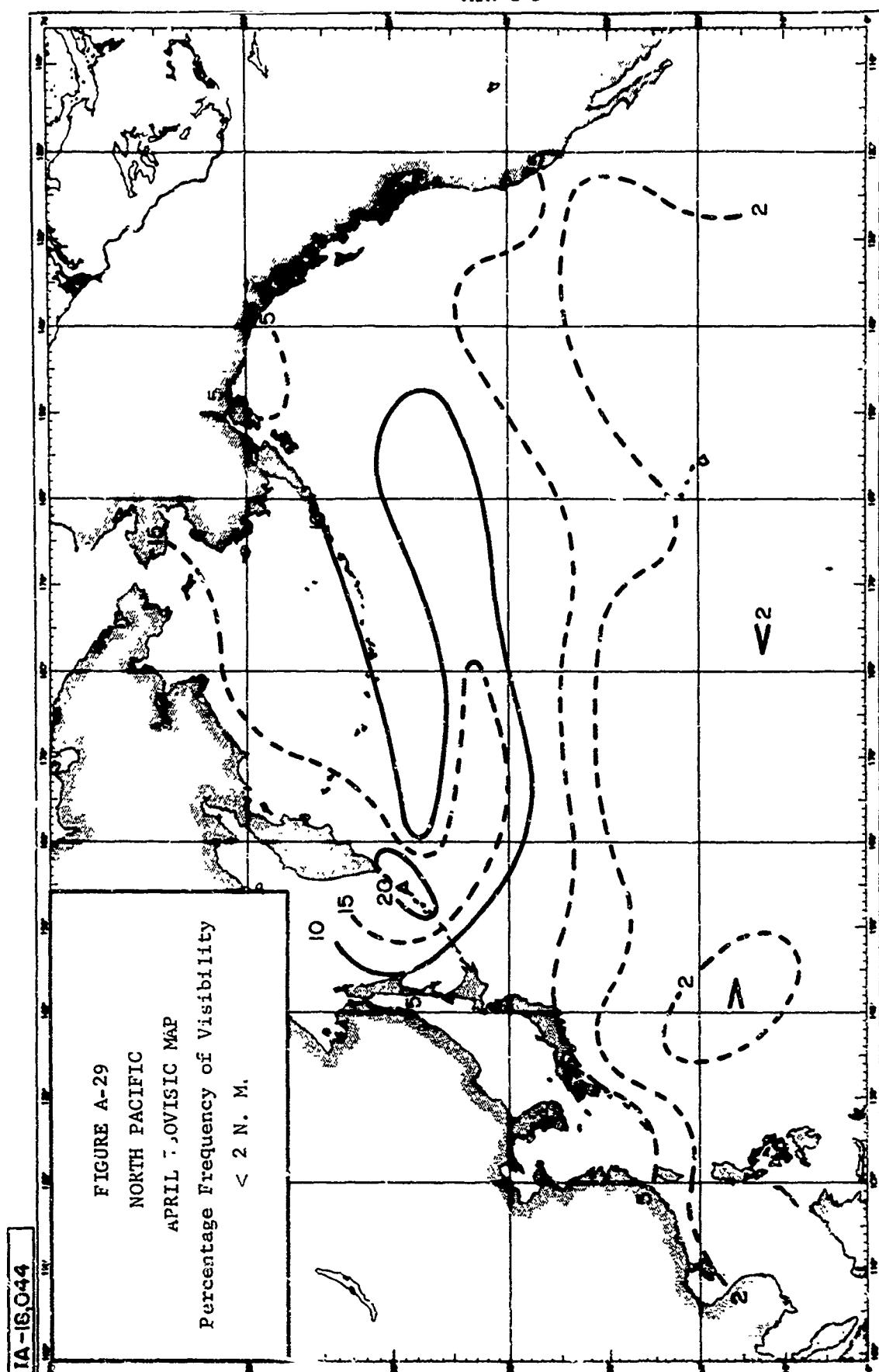
FIGURE A-27
NORTH PACIFIC OCEAN
APRIL ISOVISIC MAP
Percentage Frequency of Visibility
 < 10 N. M.



MTR-145

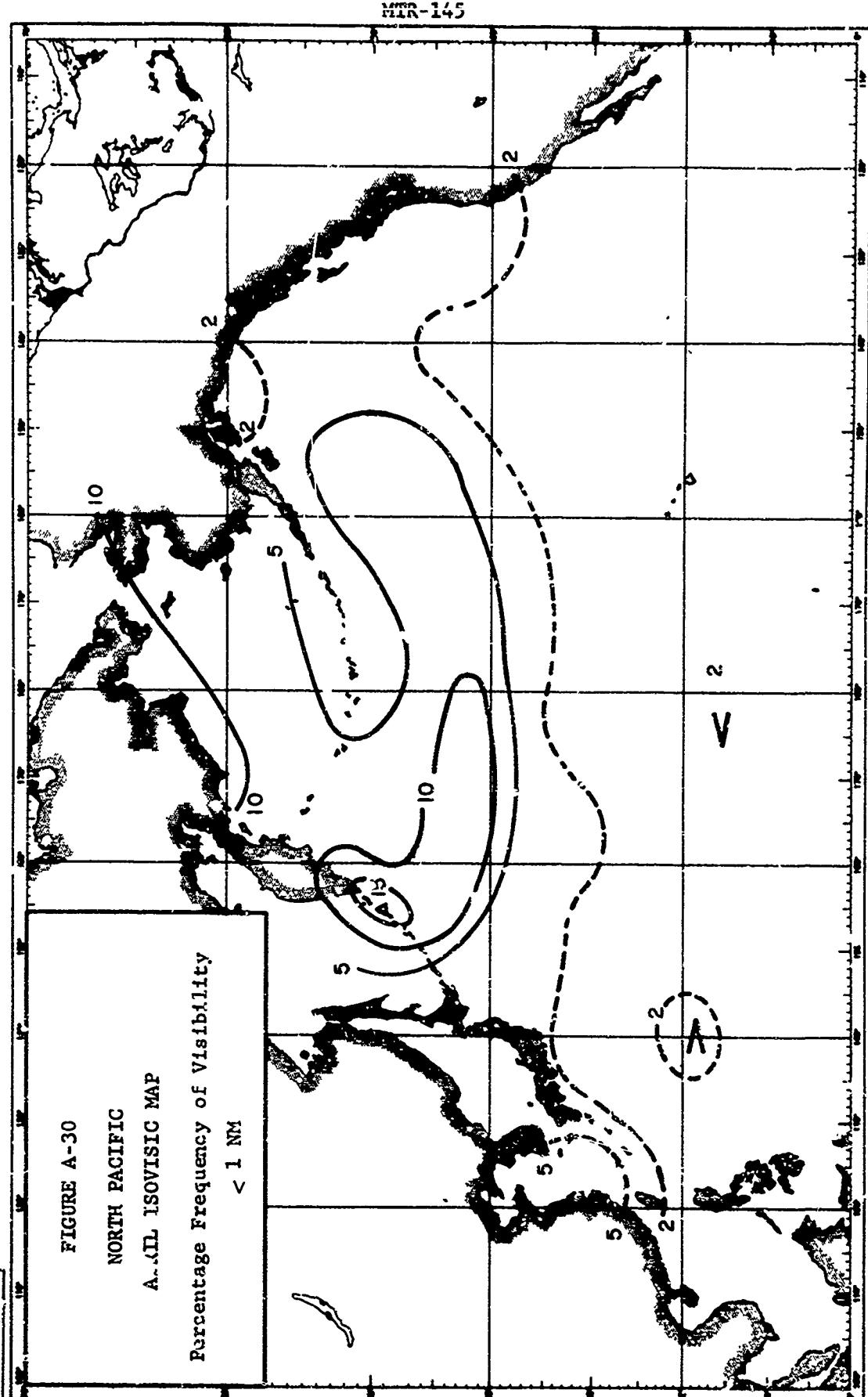


MTR-145

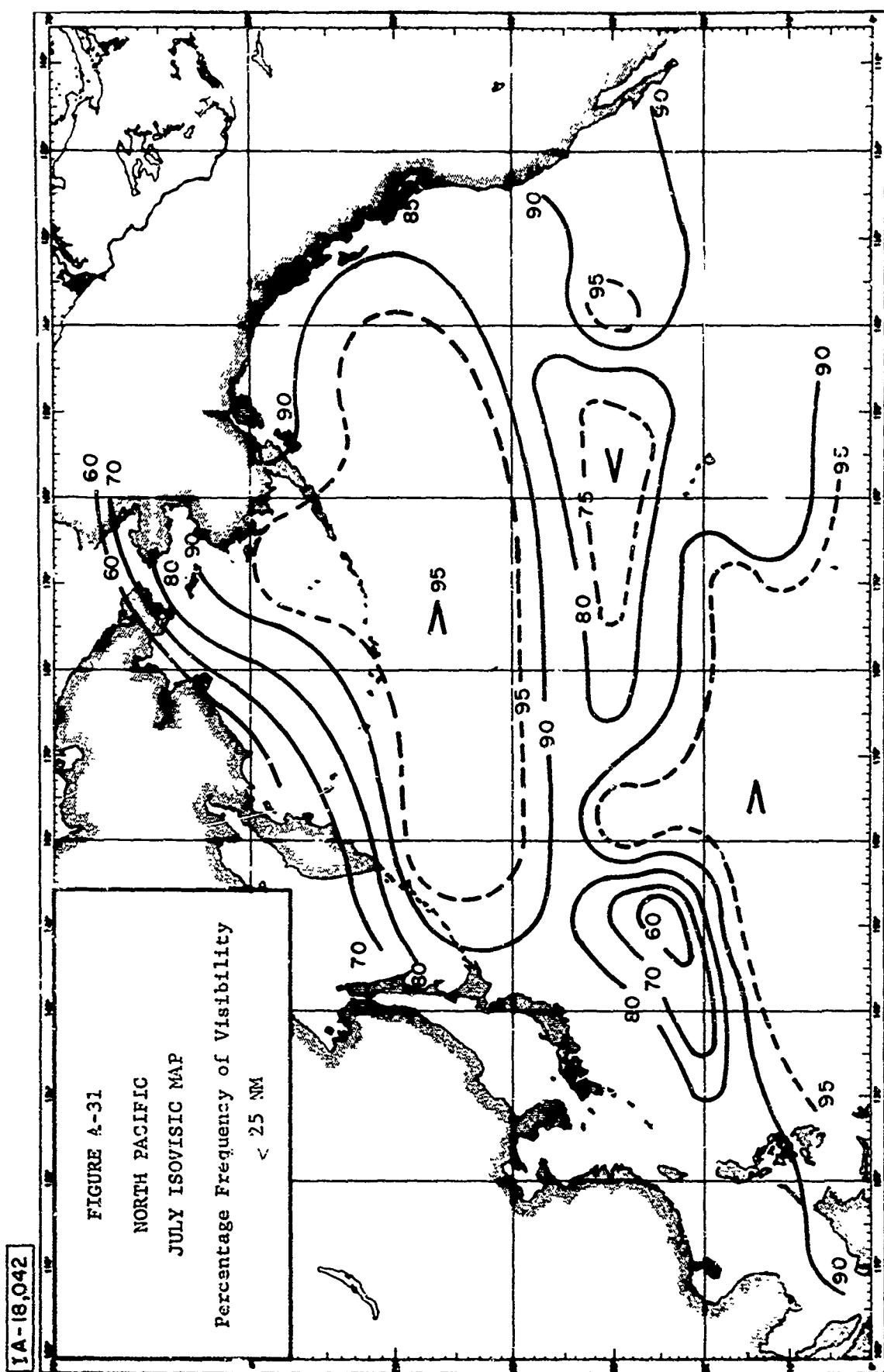


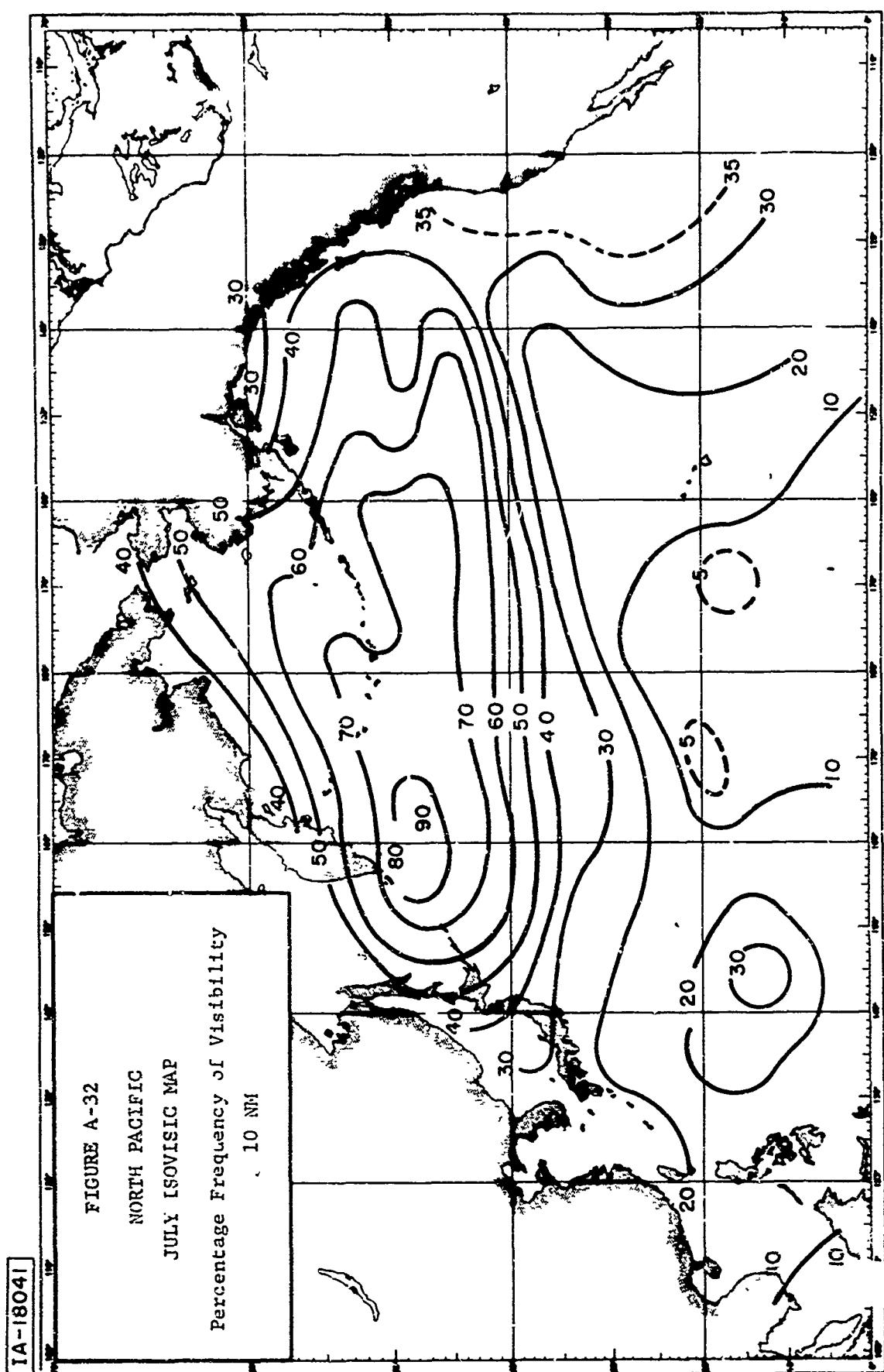
IA-18,043

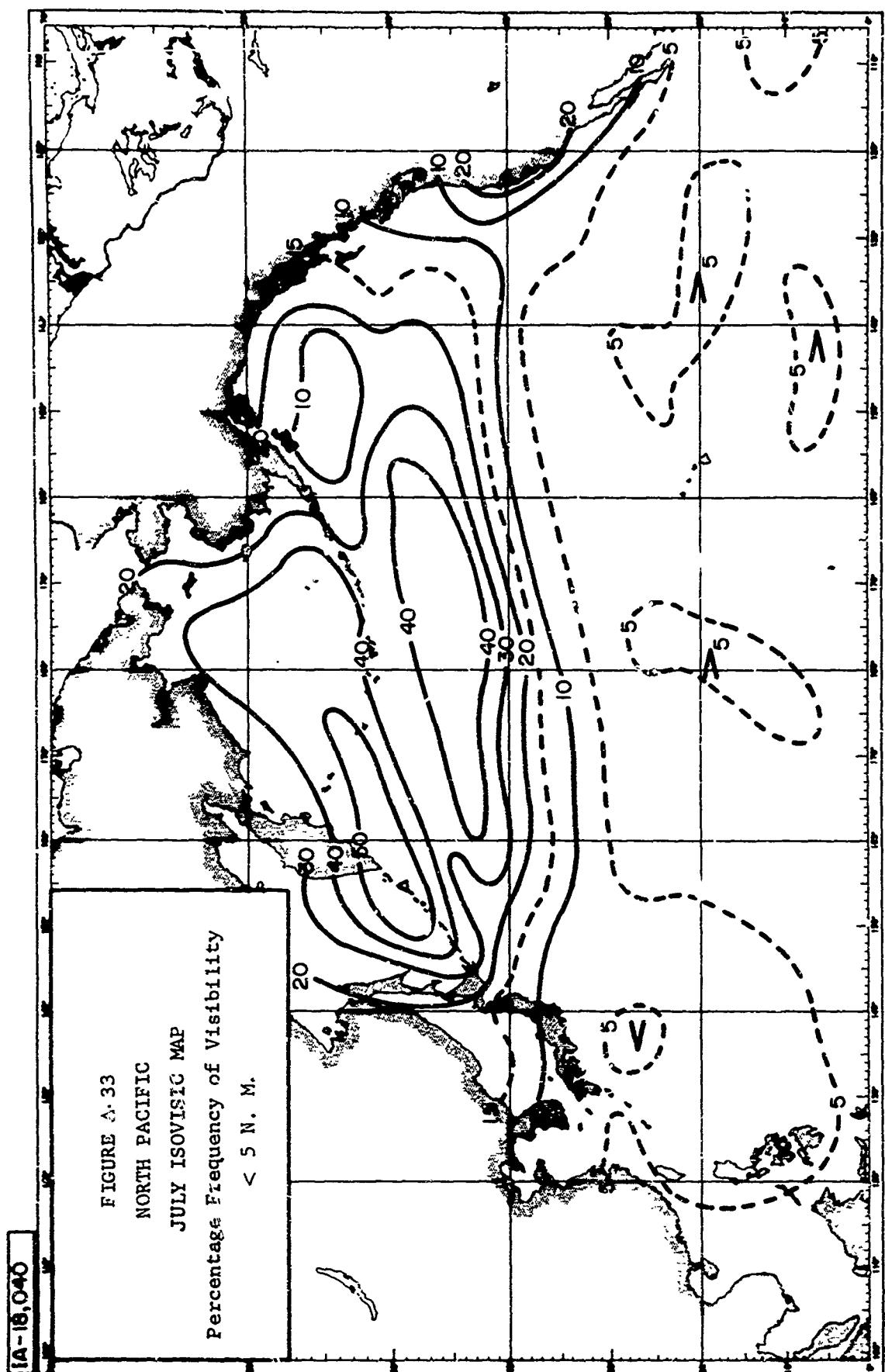
FIGURE A-30
NORTH PACIFIC
A-31 ISOVISIC MAP
Percentage Frequency of Visibility
 $< 1 \text{ NM}$



MTR-145

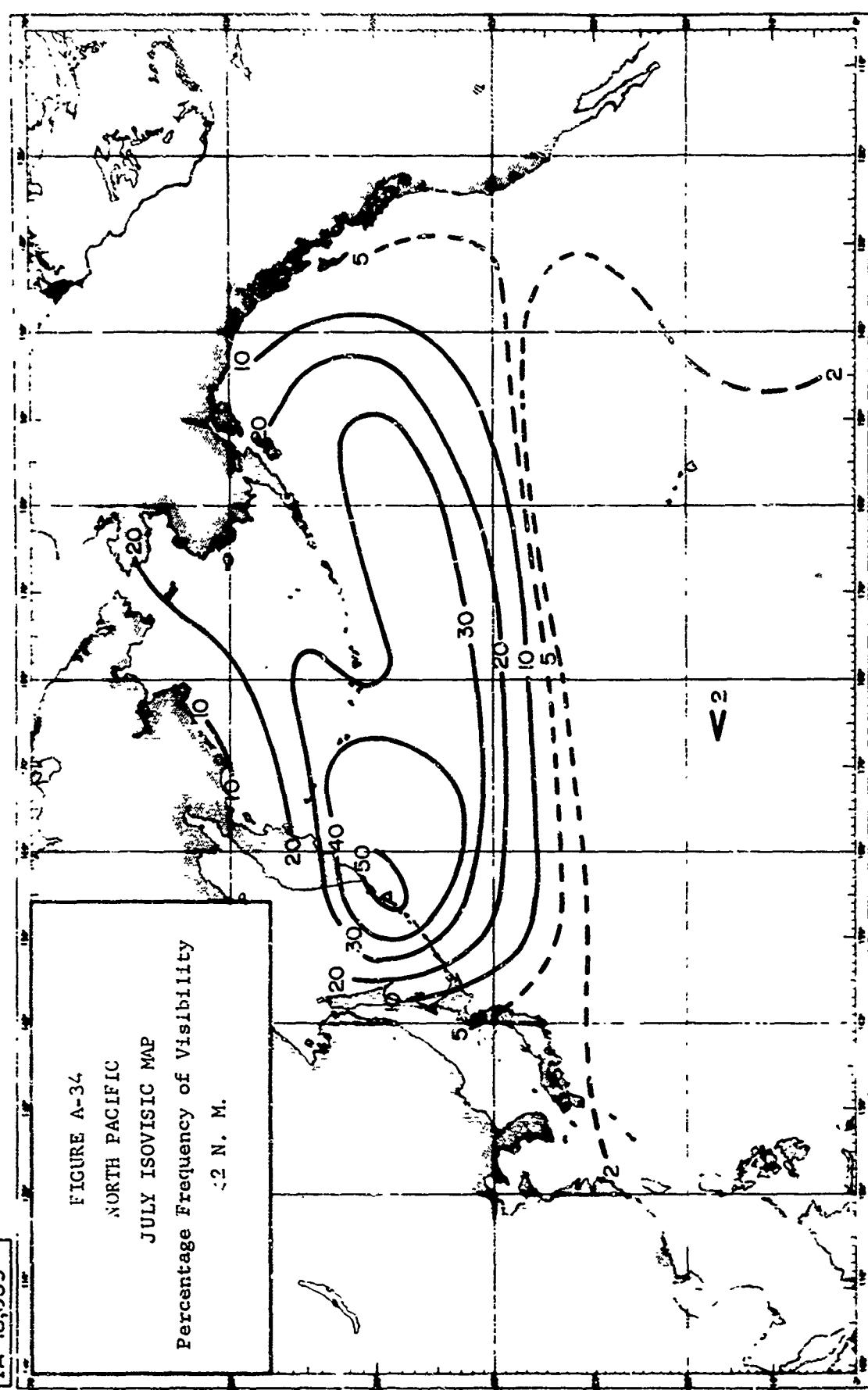




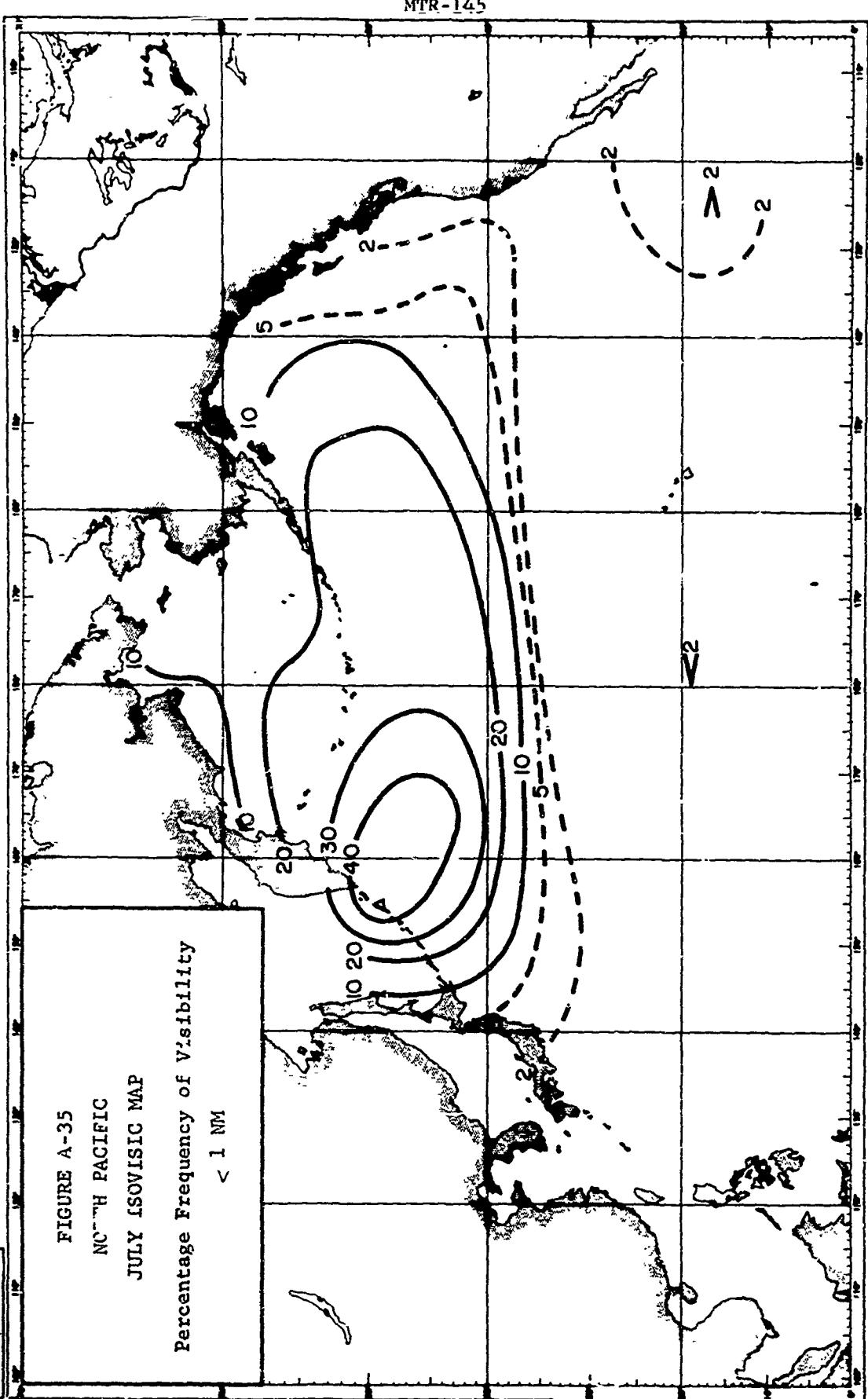


IA-18,039

FIGURE A-34
NORTH PACIFIC
JULY ISOVISIC MAP
Percentage Frequency of Visibility
≤ 2 N. M.

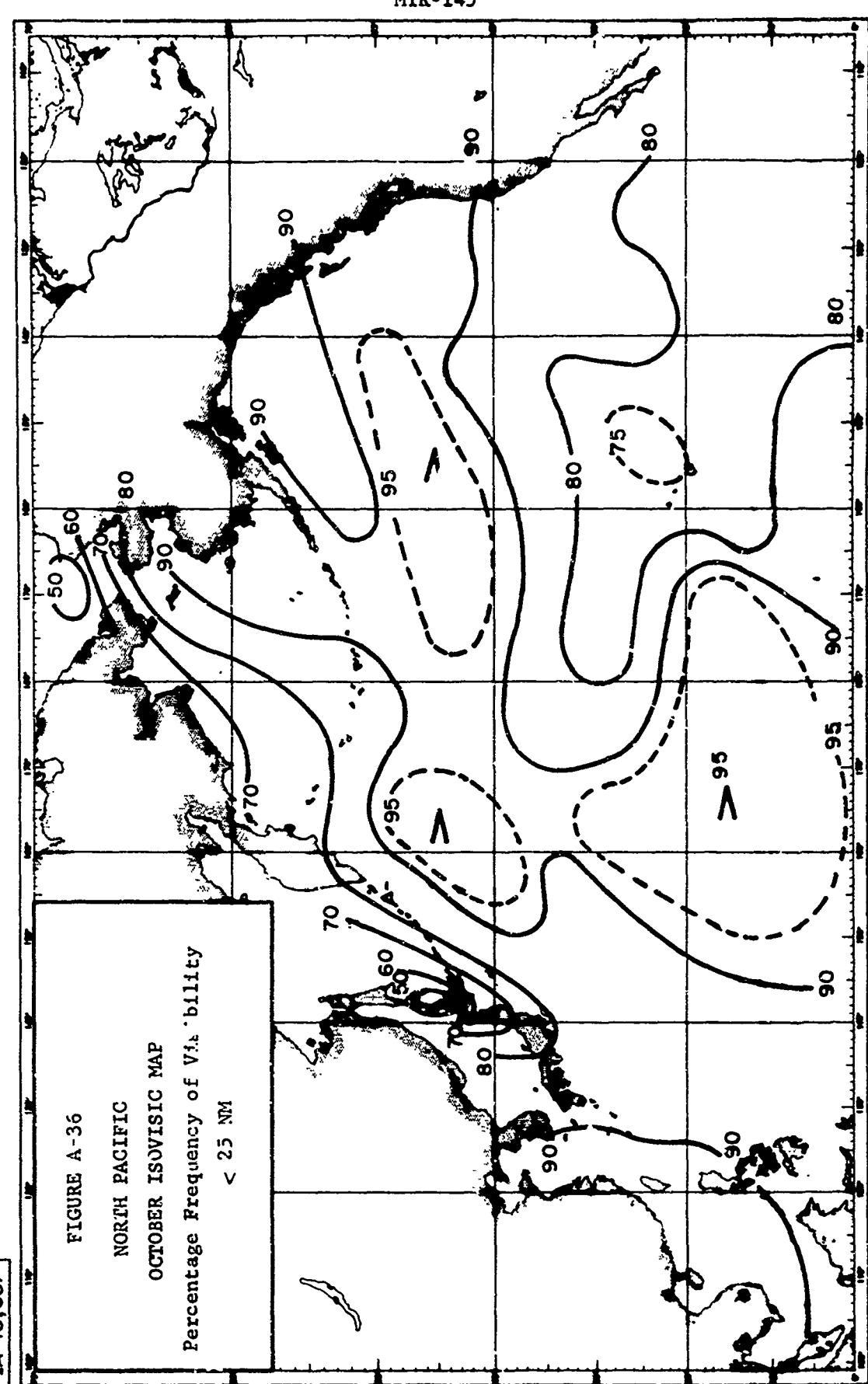


IA-18,038



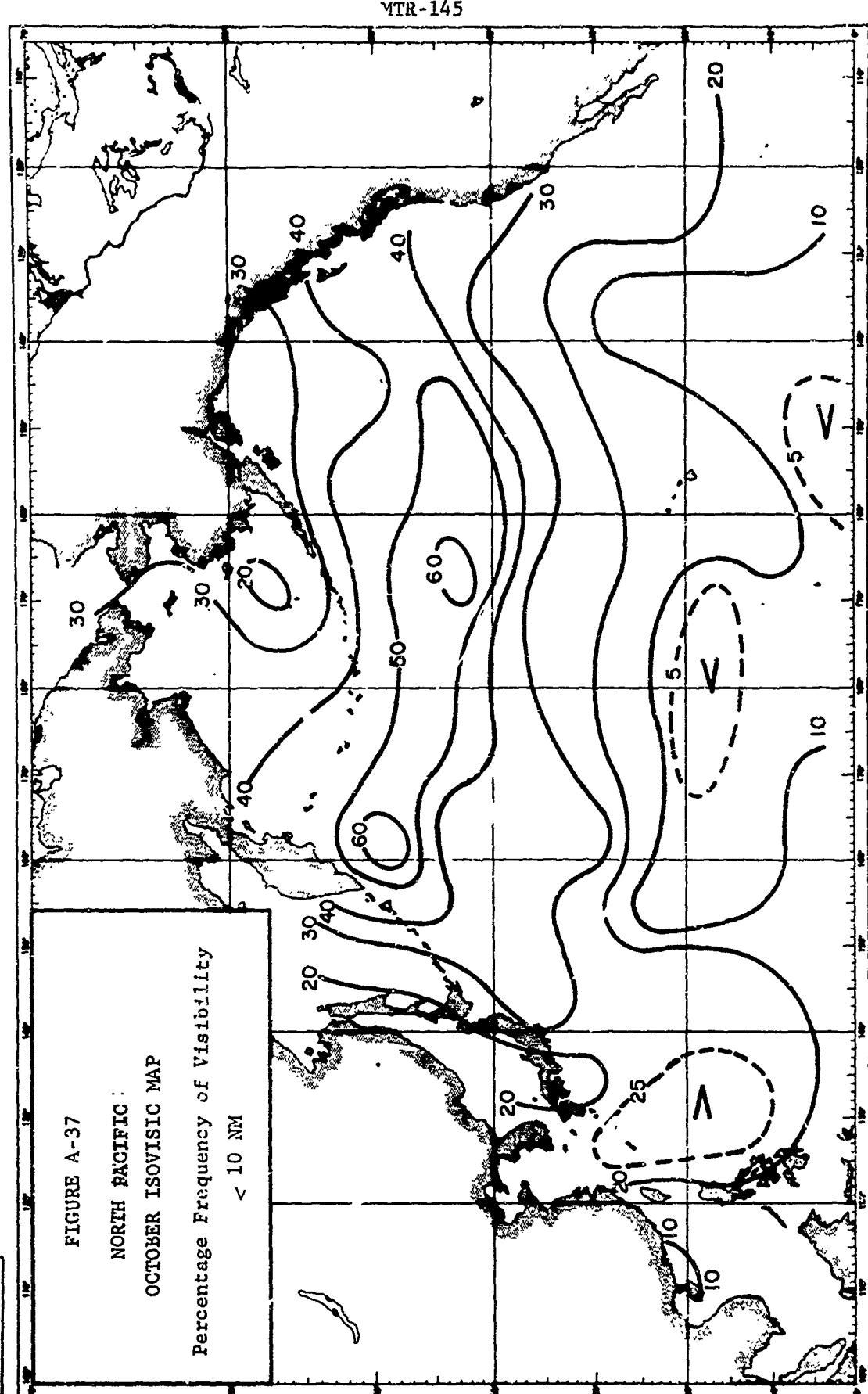
IA-18,037

FIGURE A-36
NORTH PACIFIC
OCTOBER ISOVISIC MAP
Percentage Frequency of Visibility
 < 25 NM

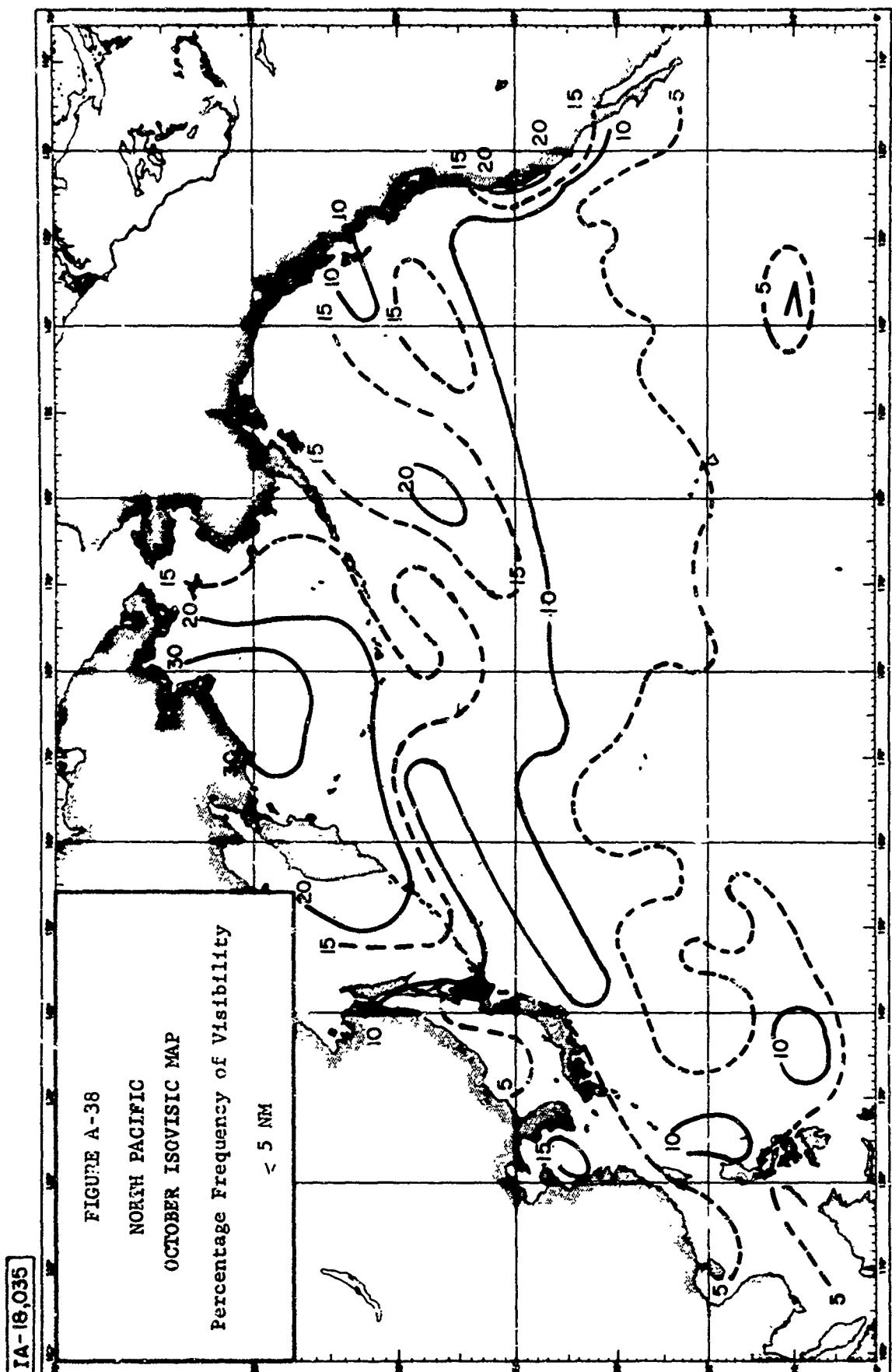


IA-18,036

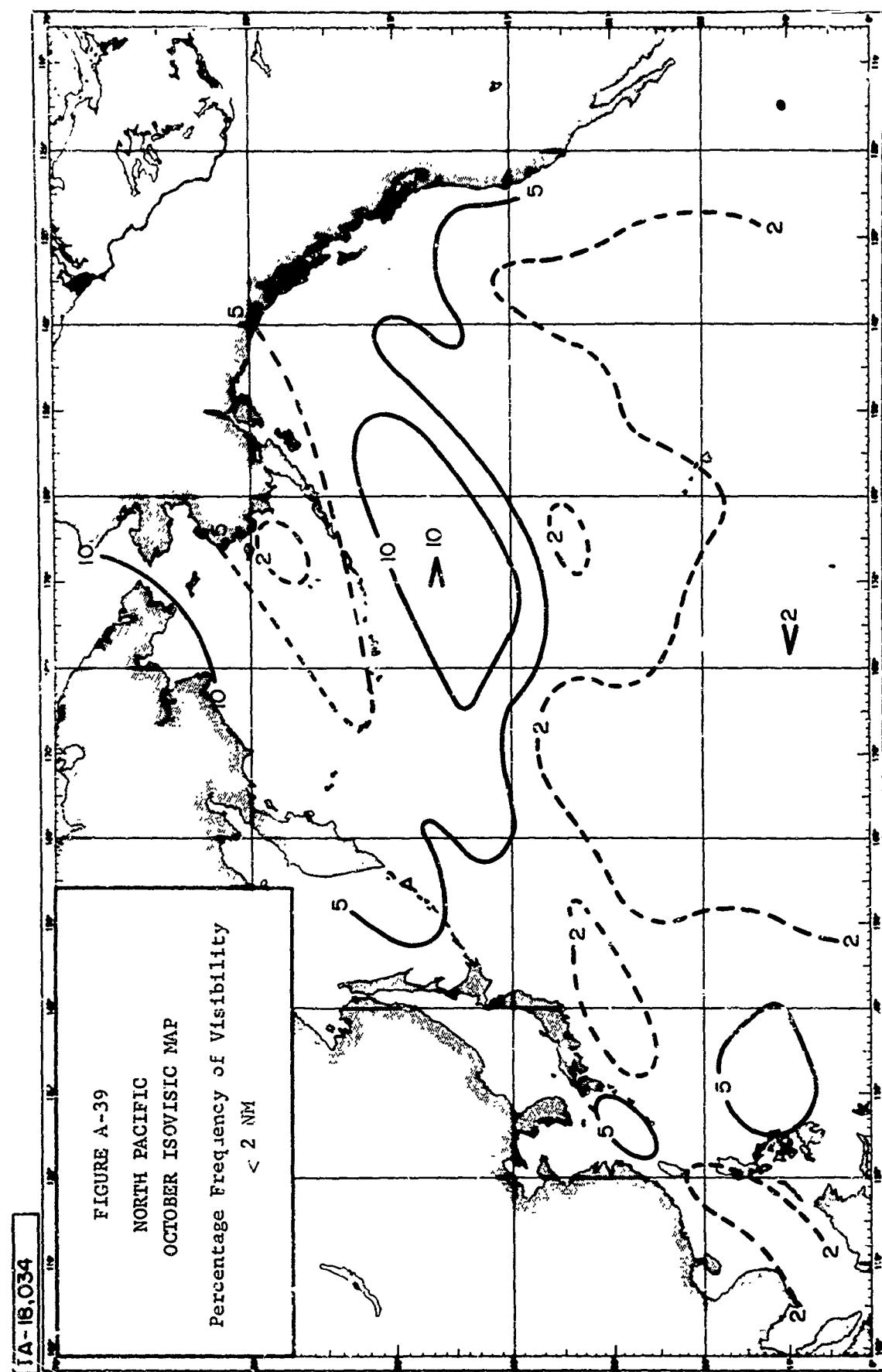
FIGURE A-37
NORTH PACIFIC
OCTOBER ISOVISIC MAP
Percentage Frequency of Visibility
< 10 NM

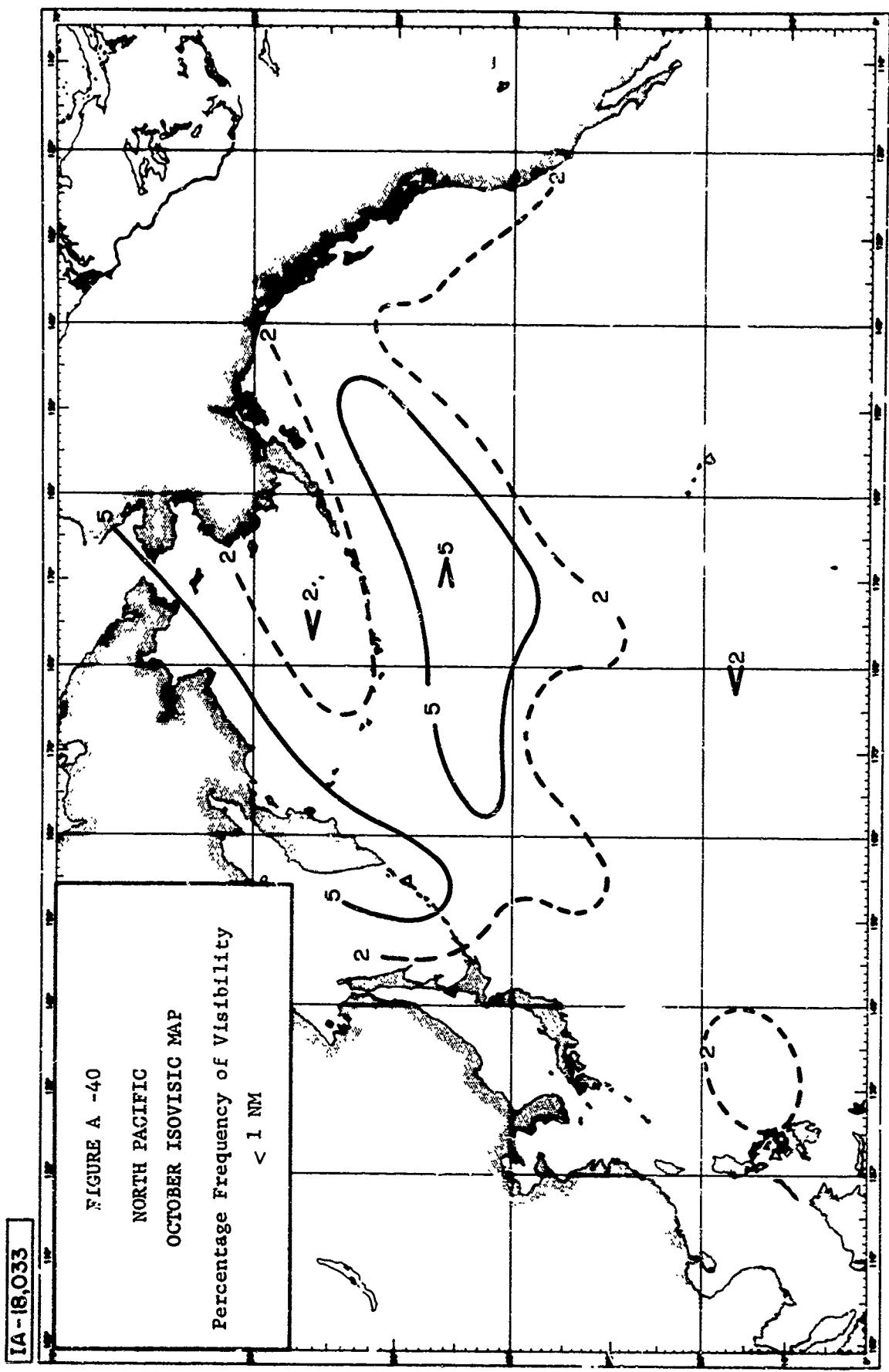


MTR-145



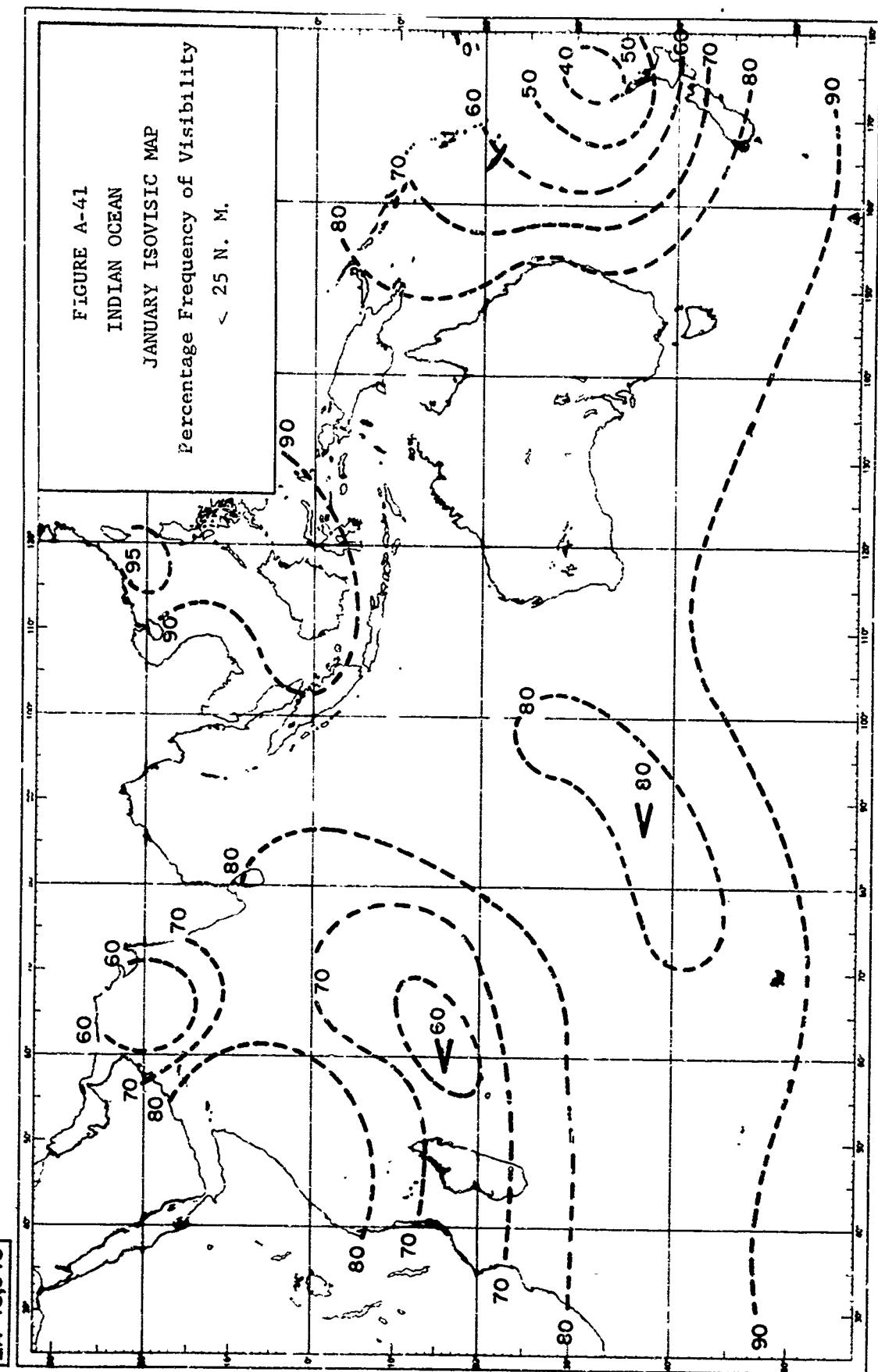
YTR-145



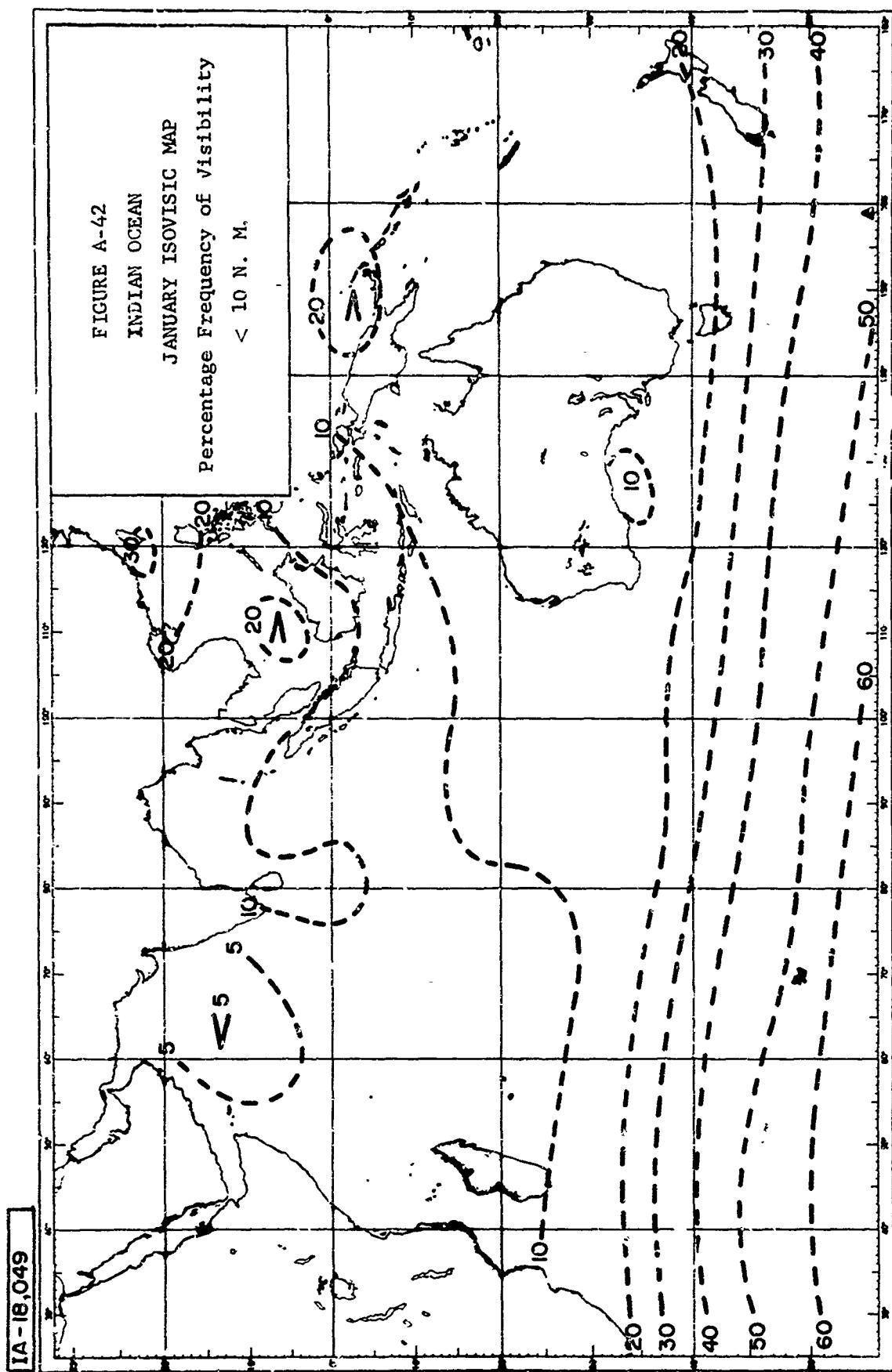


IA-18,048

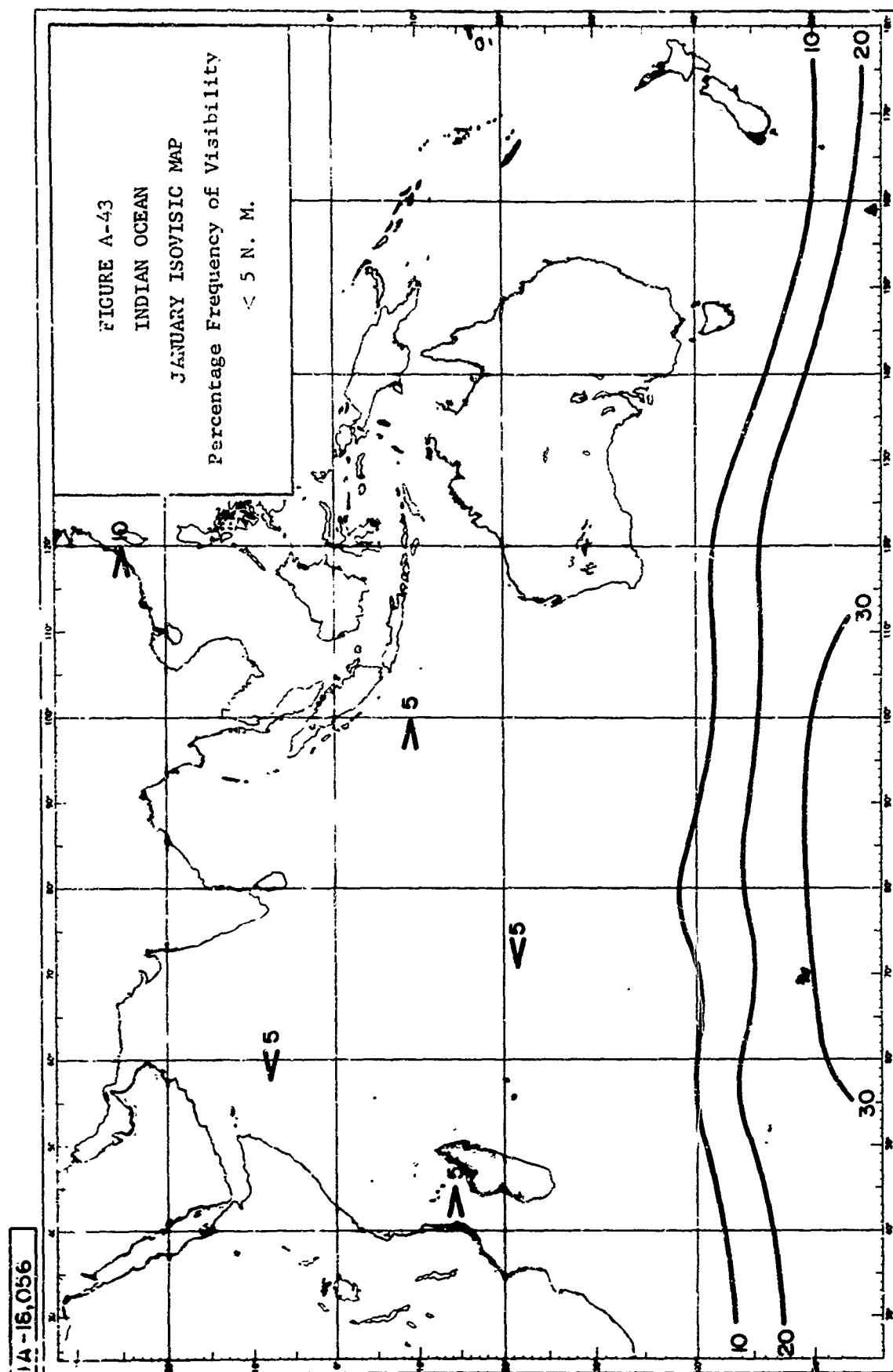
MTR-145



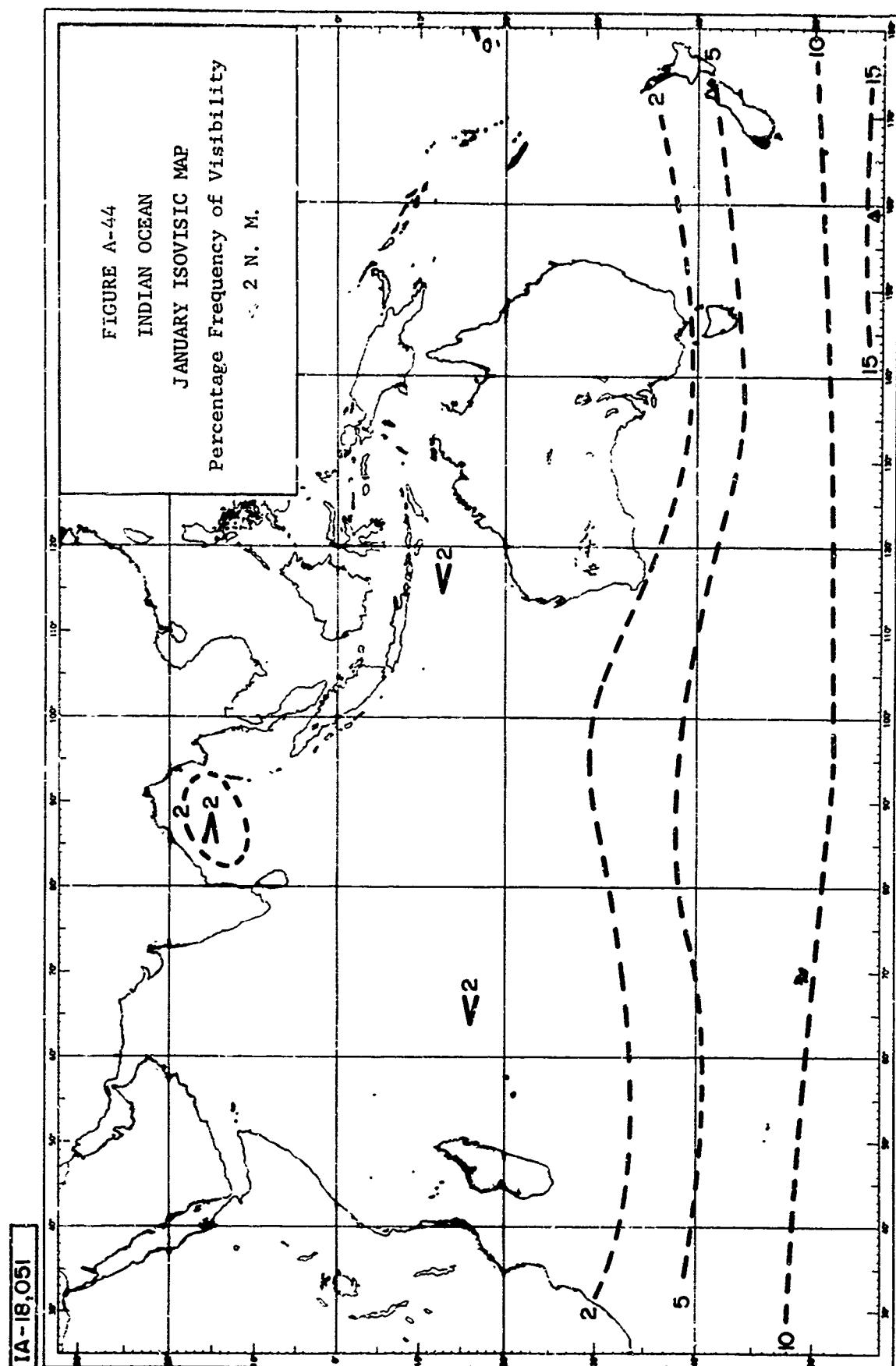
MTR-145



MTR-145



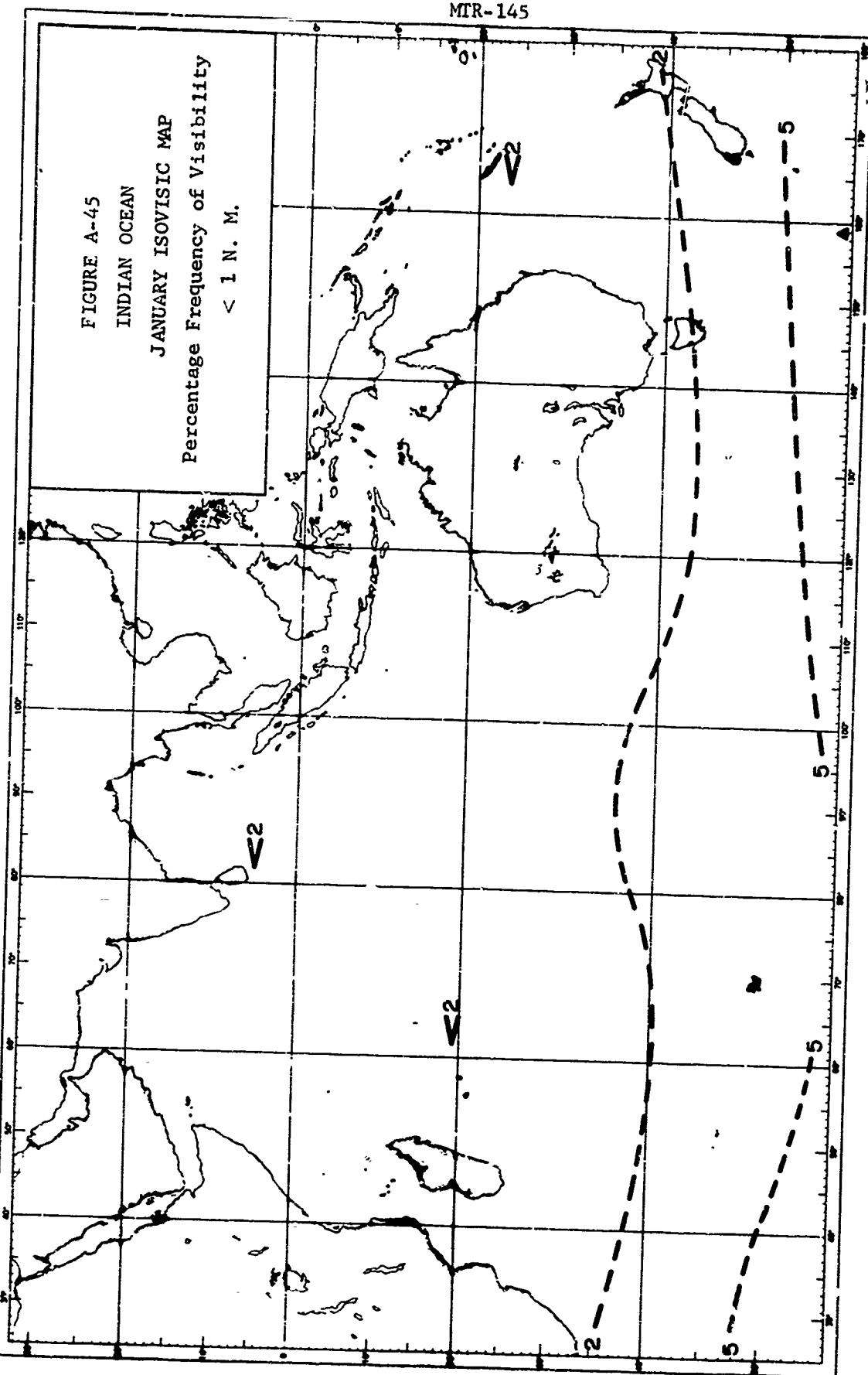
MTR-145



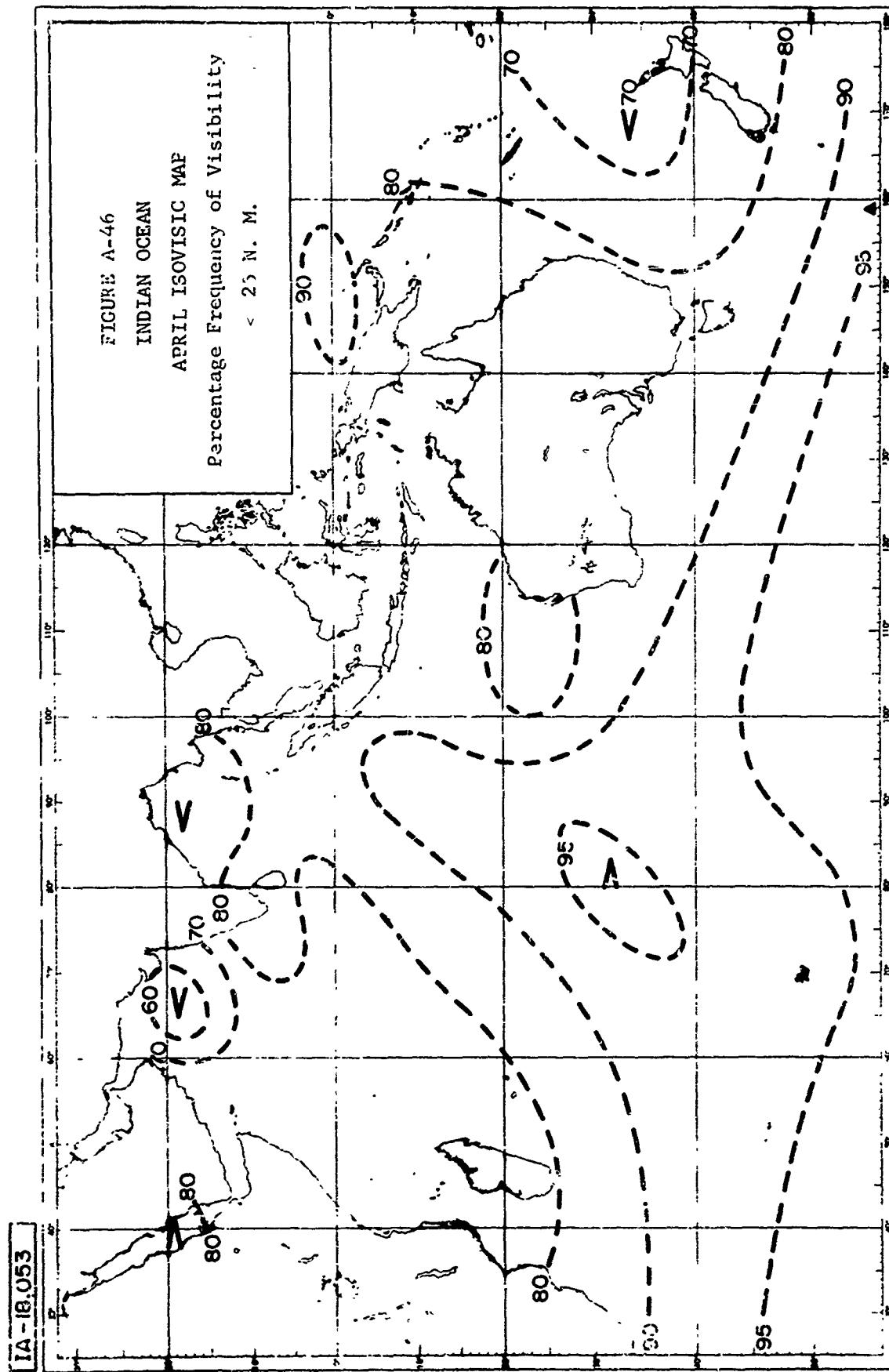
EA - 18,051

A-45

IA-18,032



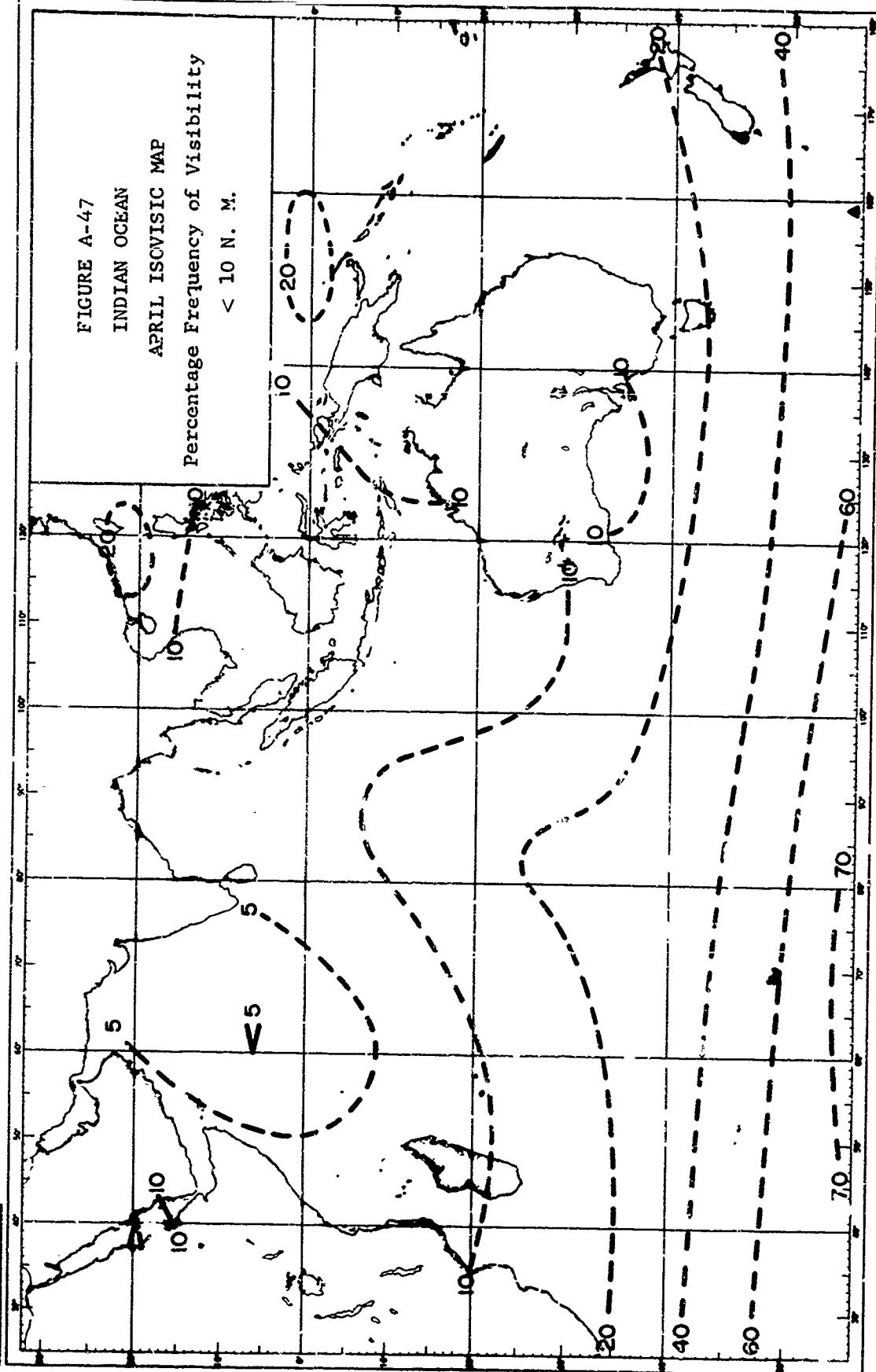
MTR-145



IA-18,054

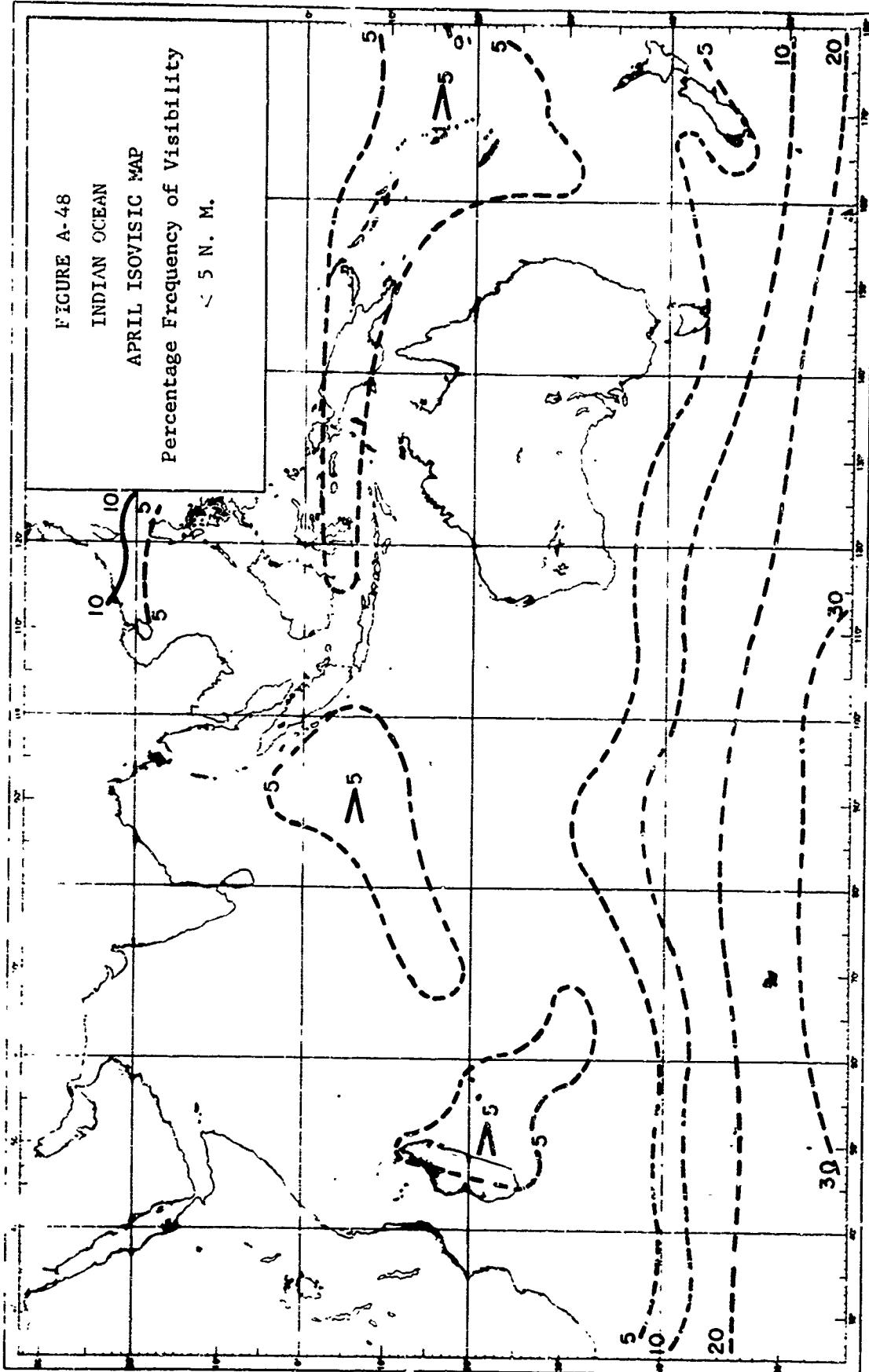
MTR-145

FIGURE A-47
INDIAN OCEAN
APRIL ISCOVISIC MAP
Percentage Frequency of Visibility
 < 10 N. M.



IA-18,055

FIGURE A-48
INDIAN OCEAN
APRIL ISOVISIC MAP
Percentage Frequency of Visibility
< 5 N. M.



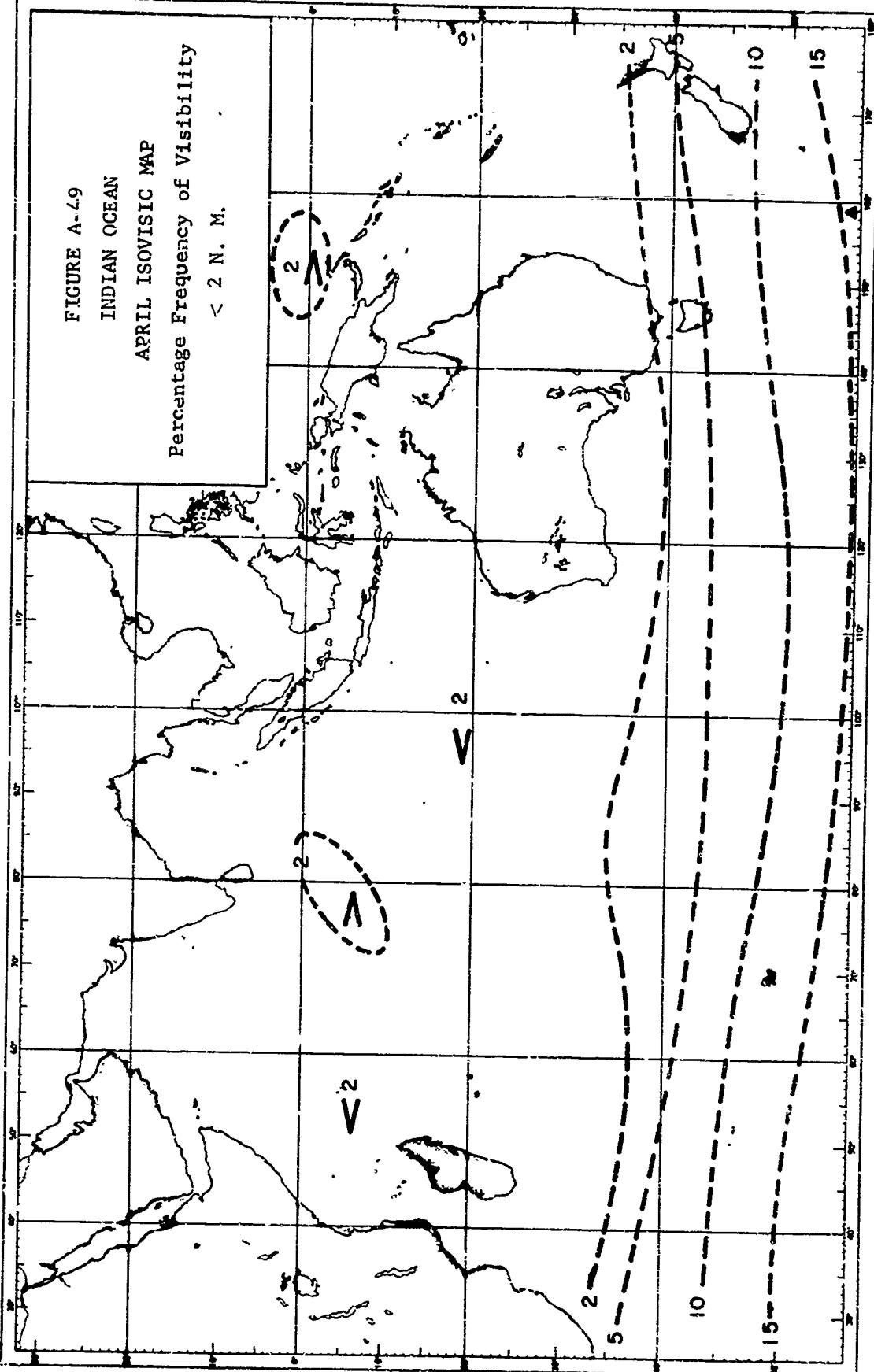
A-49

MTR-145

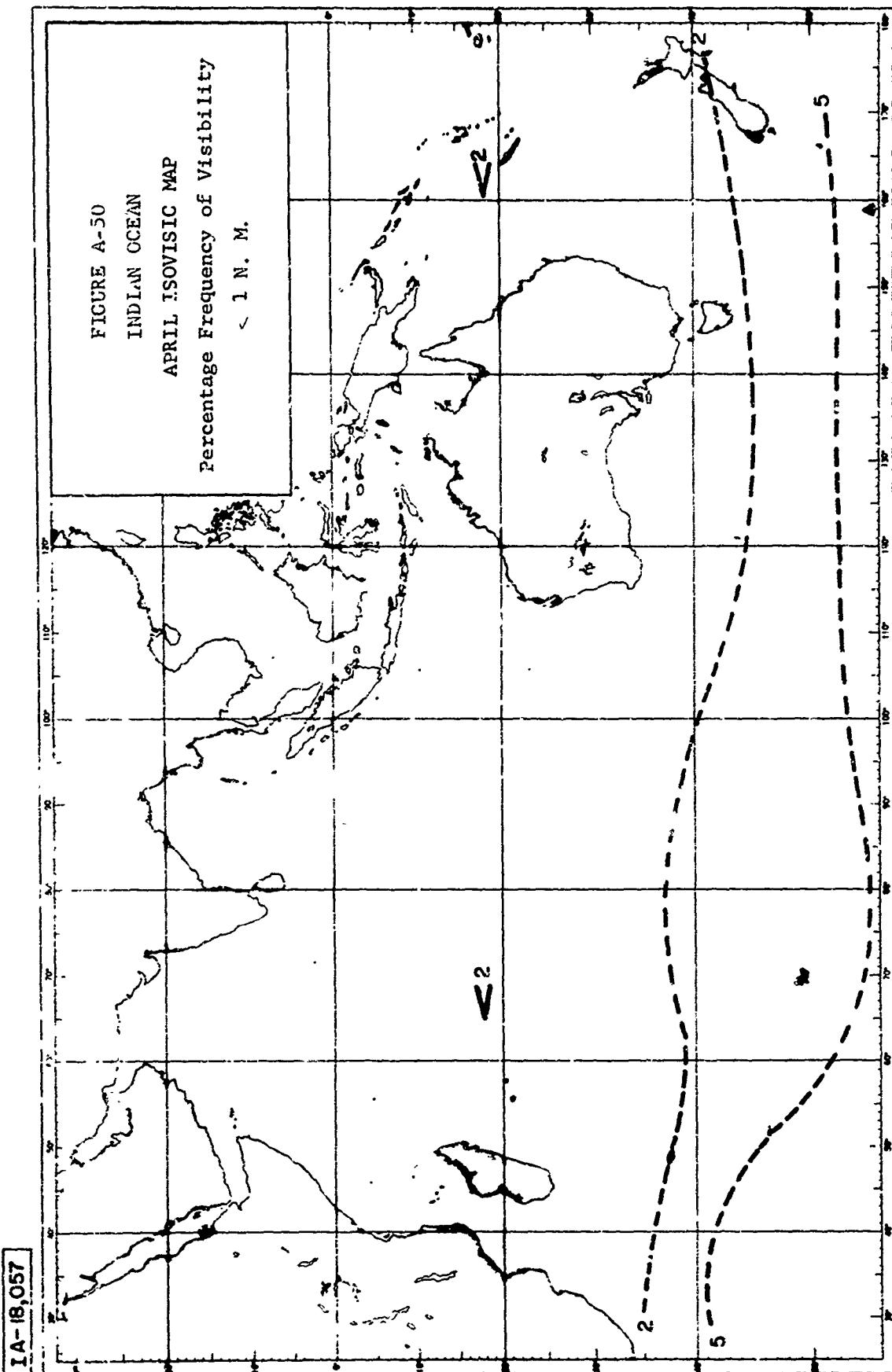
IA-18,056

MTR-145

FIGURE A-49
INDIAN OCEAN
APRIL ISOVISIC MAP
Percentage Frequency of Visibility
 < 2 N. M.



MTR-145

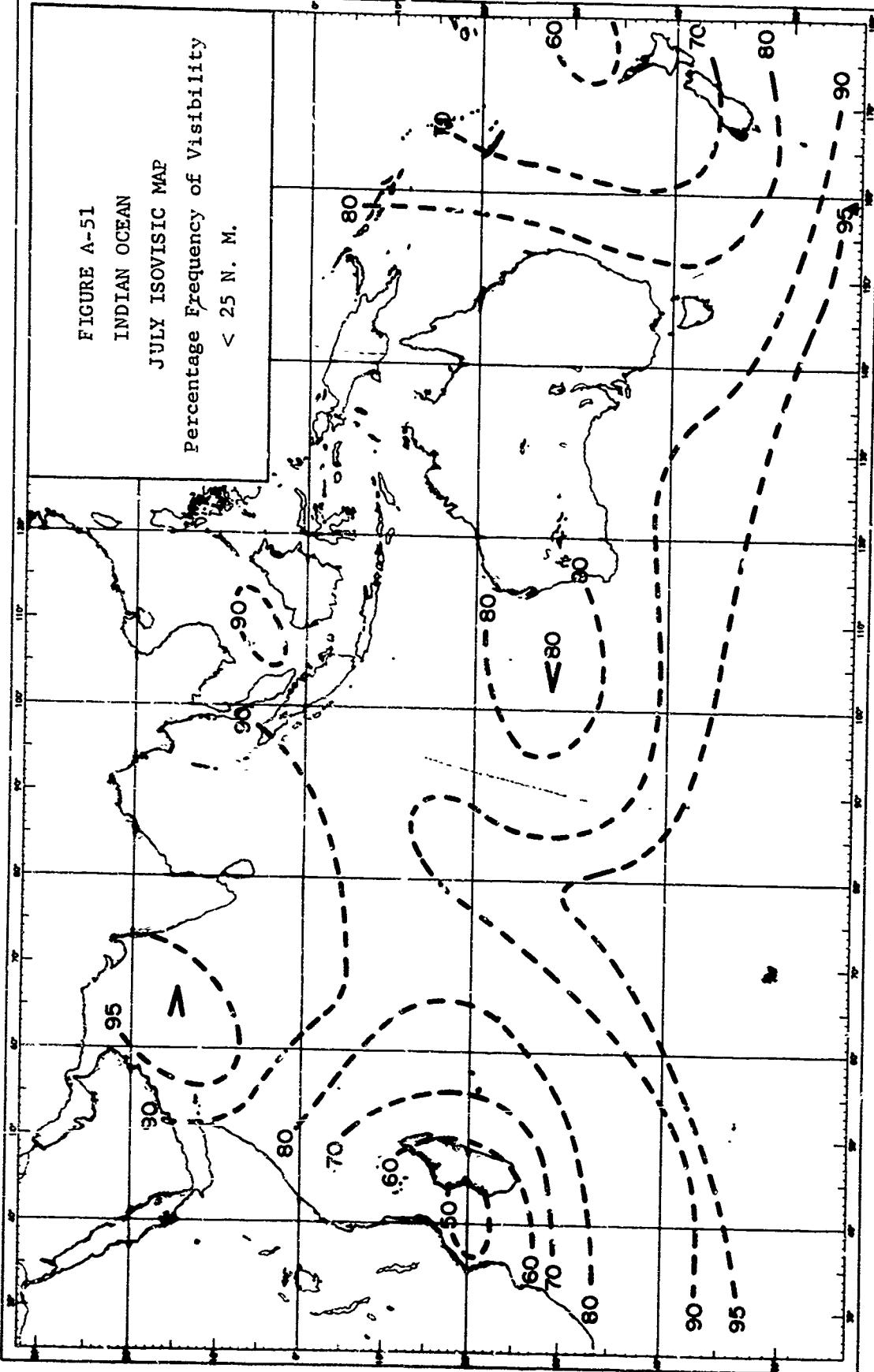


IA-18,058

FIGURE A-51
INDIAN OCEAN
JULY ISOVISIC MAP

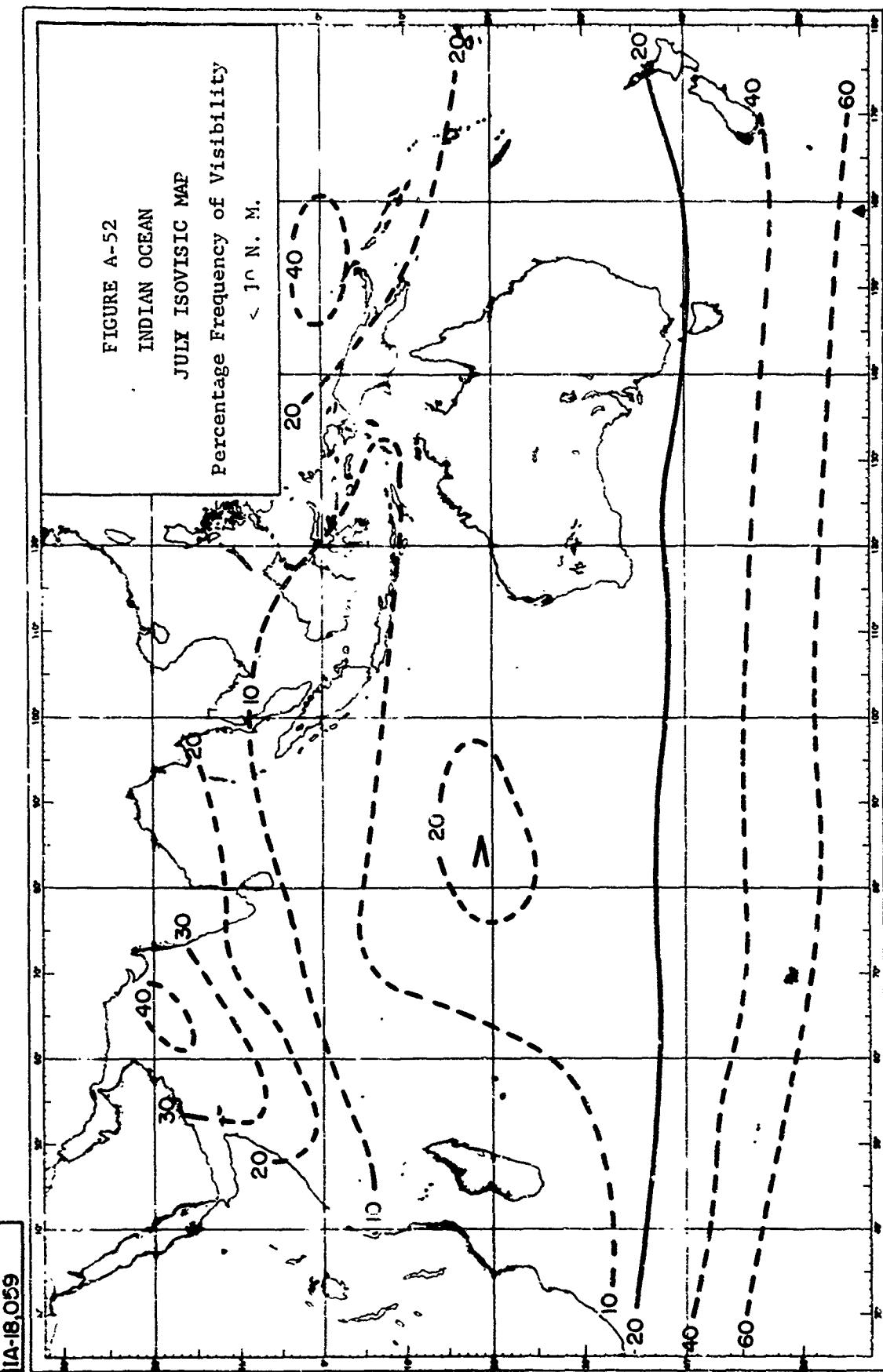
Percentage Frequency of Visibility
< 25 N. M.

MTR-145



A-52

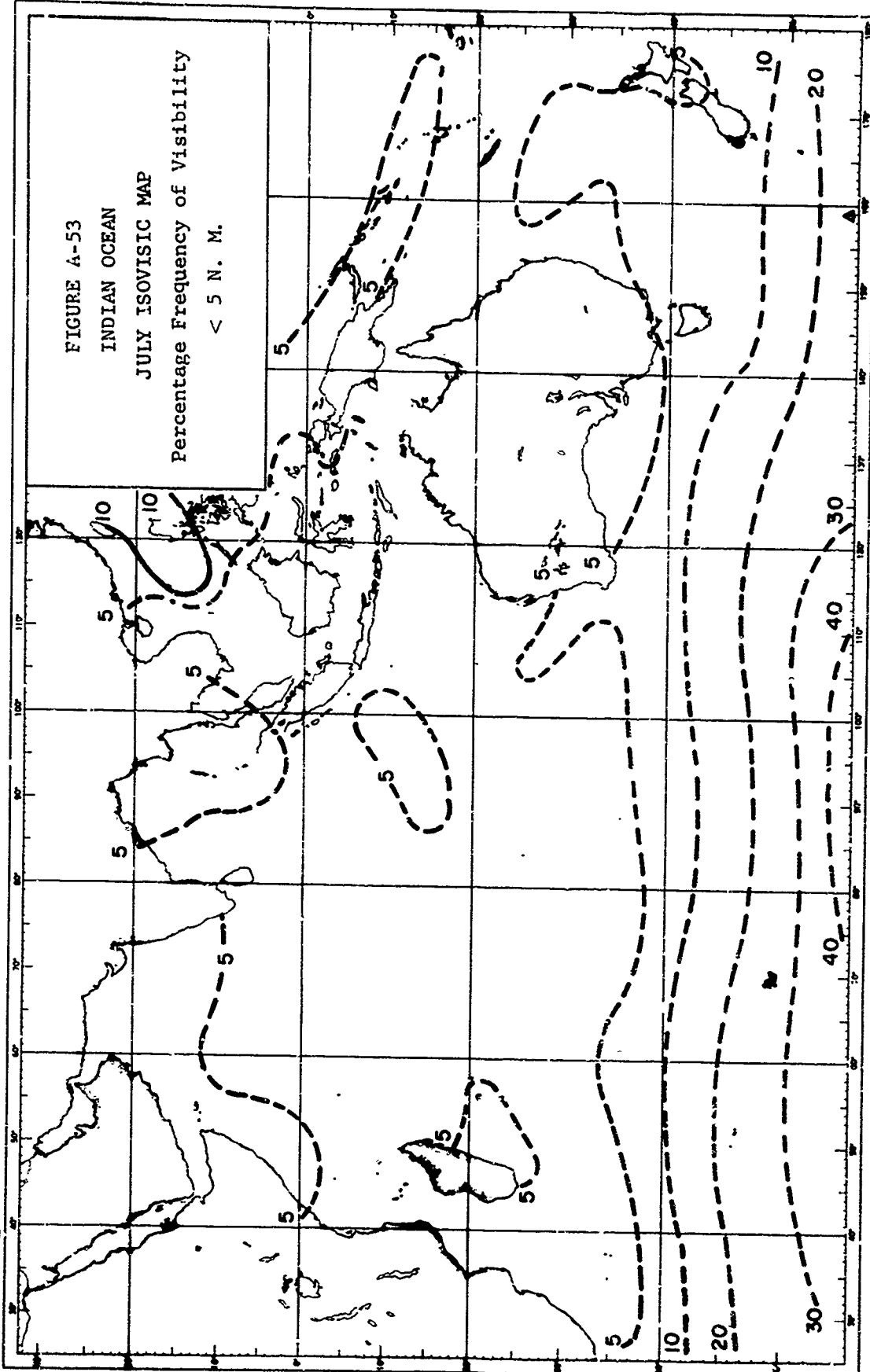
MTR-145



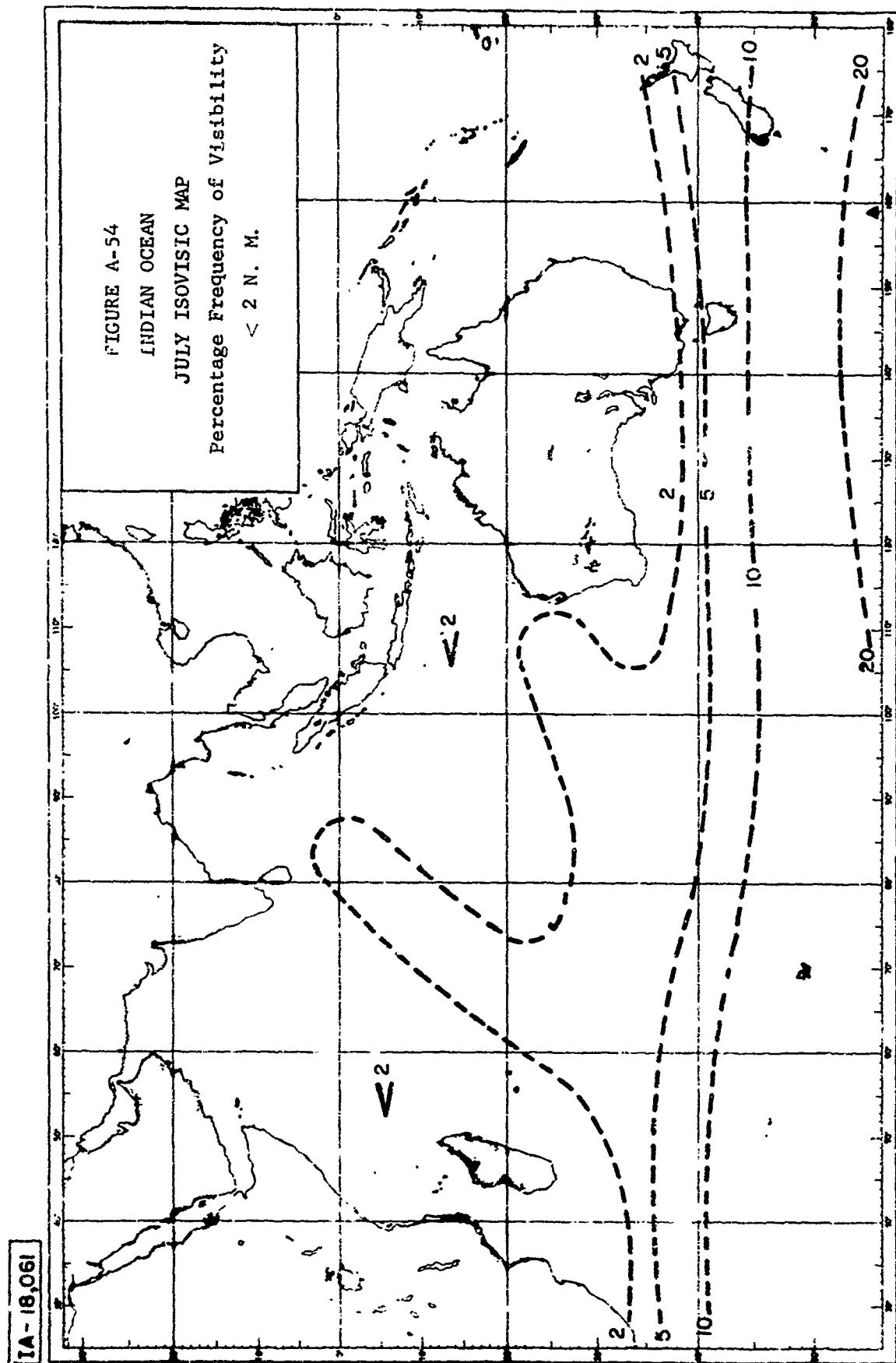
MTR-145

IA-18 P60

FIGURE A-53
INDIAN OCEAN
JULY ISOVISTIC MAP
Percentage Frequency of Visibility
 < 5 N. M.



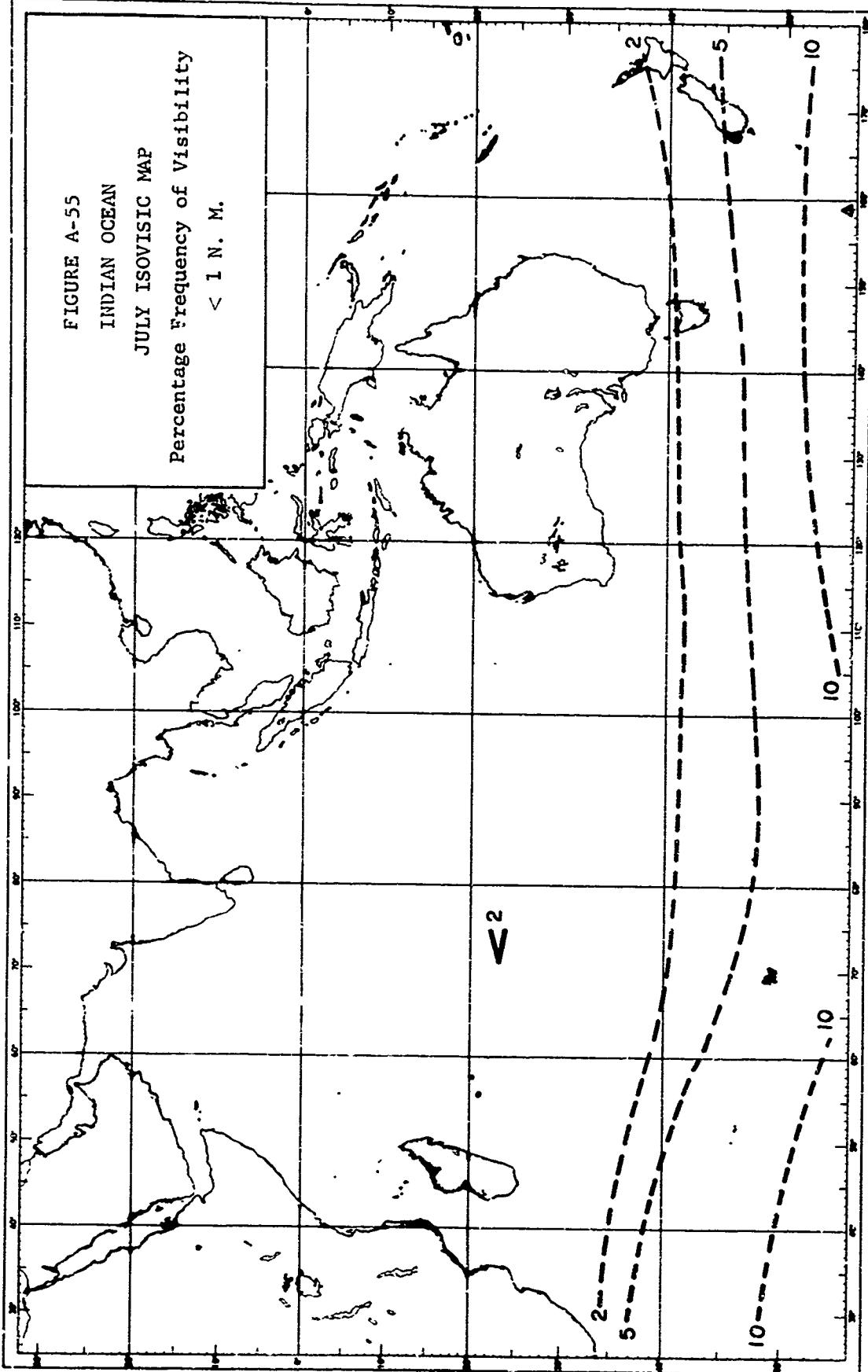
MFR-145



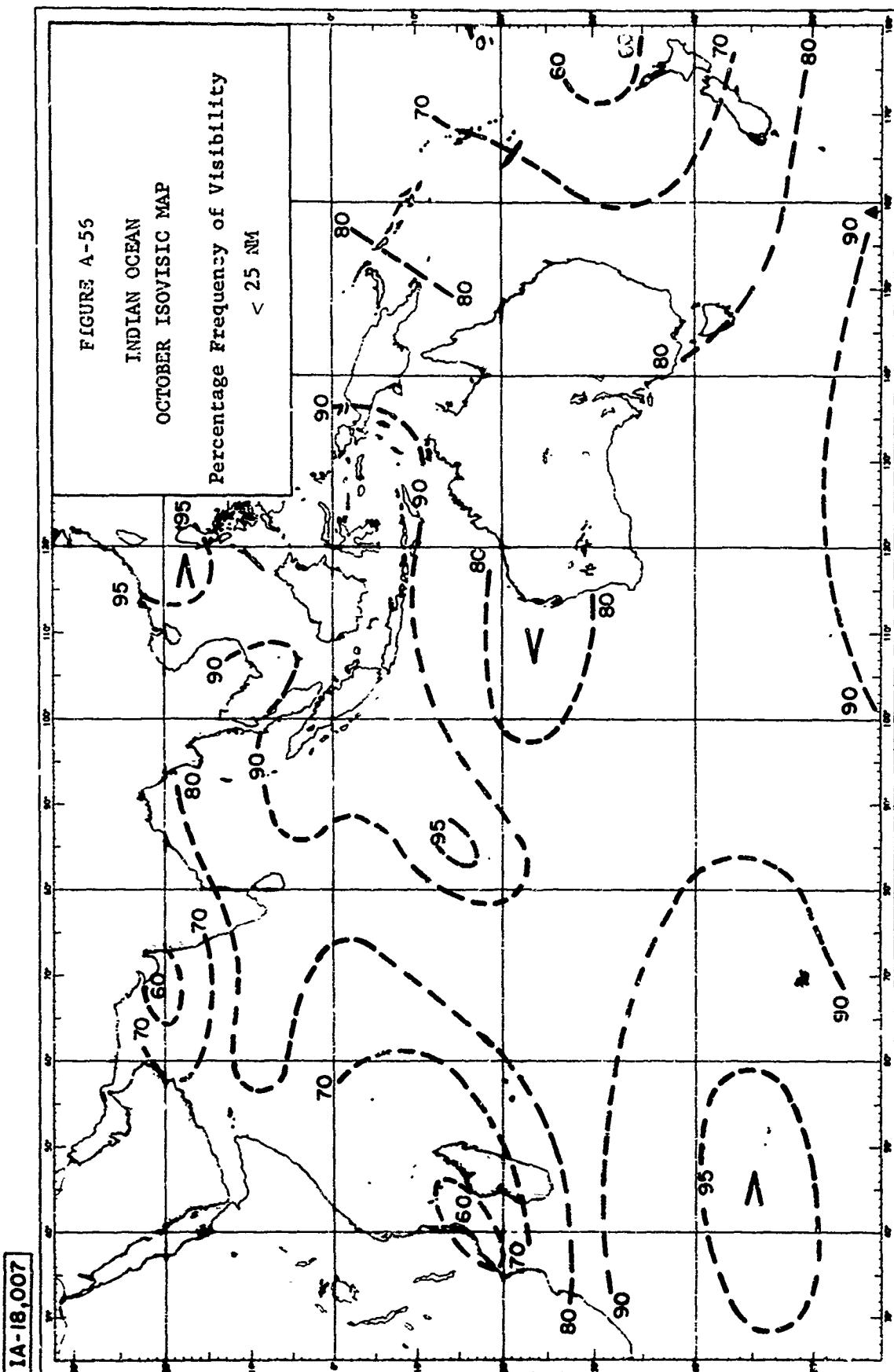
IA-18,062

FIGURE A-55
INDIAN OCEAN
JULY ISOVISIC MAP
Percentage Frequency of Visibility
 < 1 N. M.

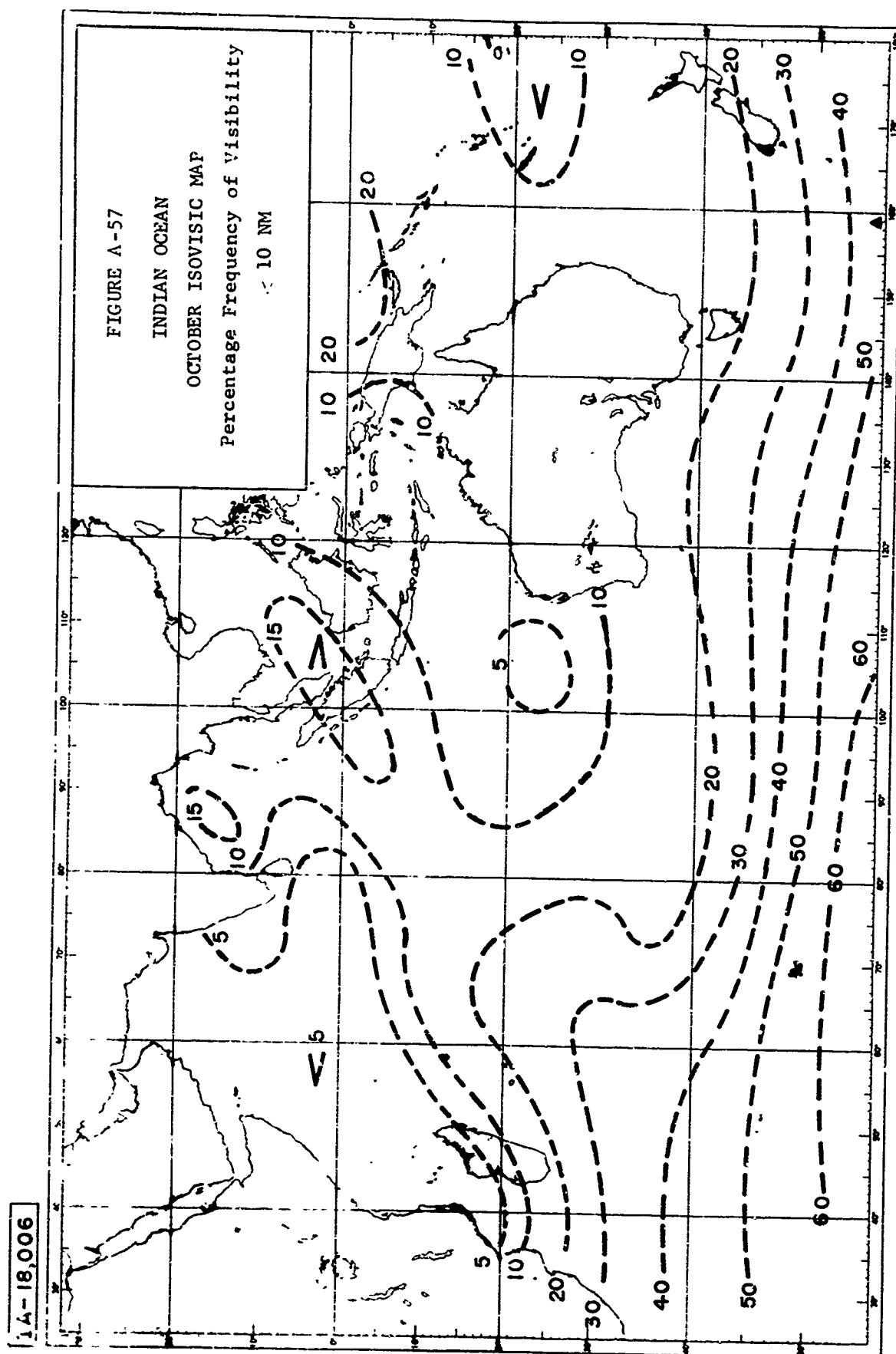
MTR=145



MTR-145

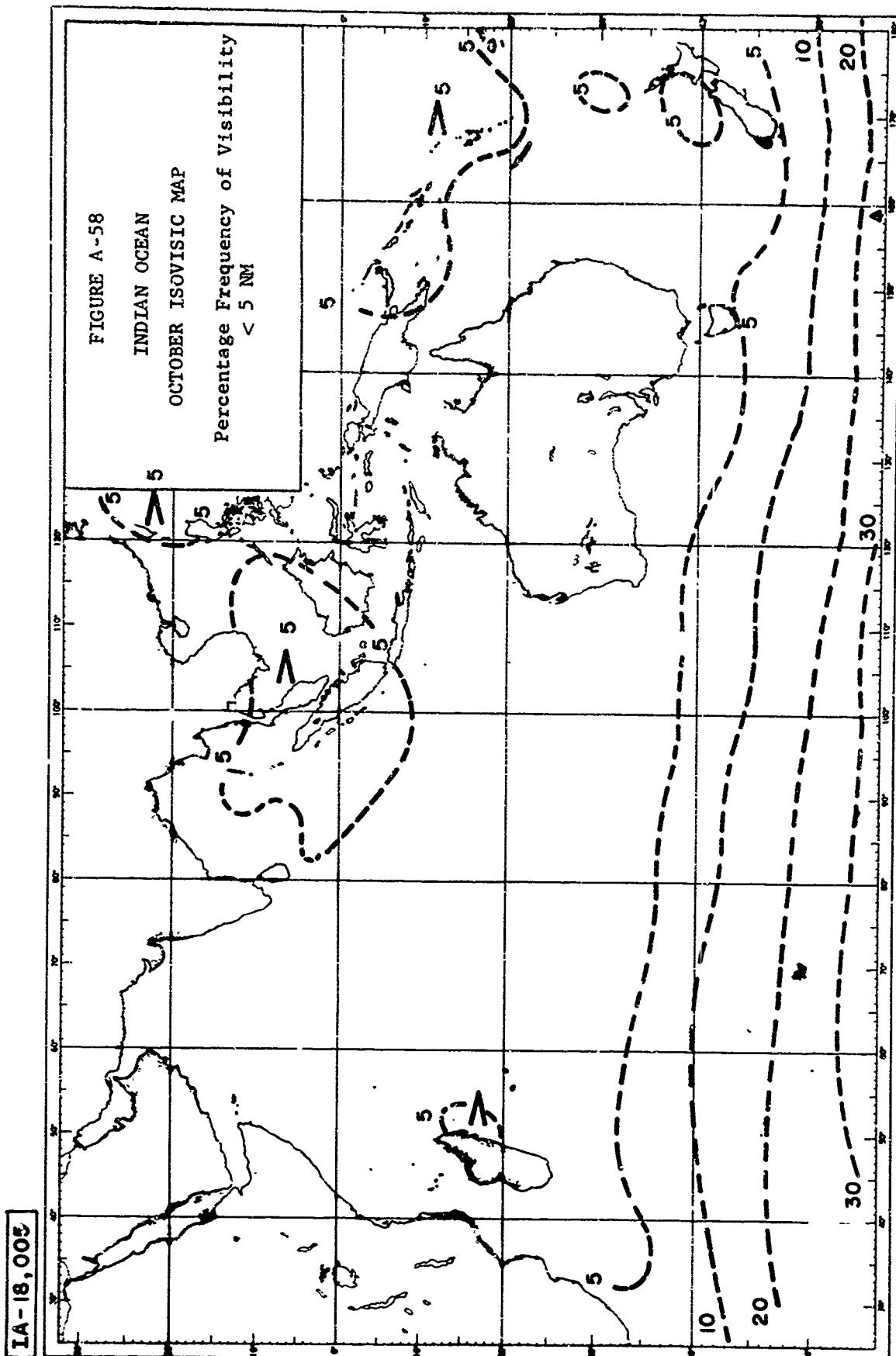


MTR-145

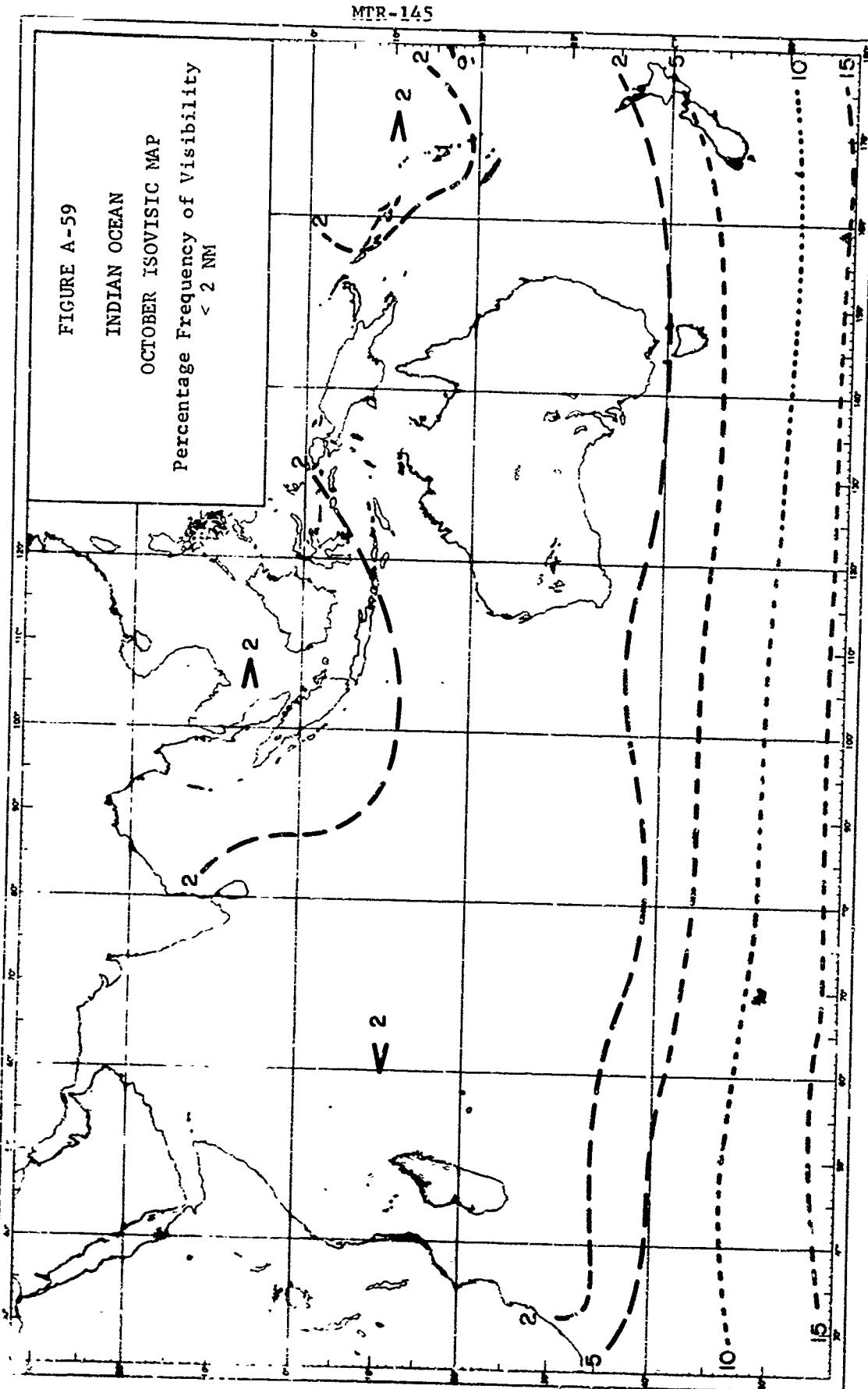


14-18,006

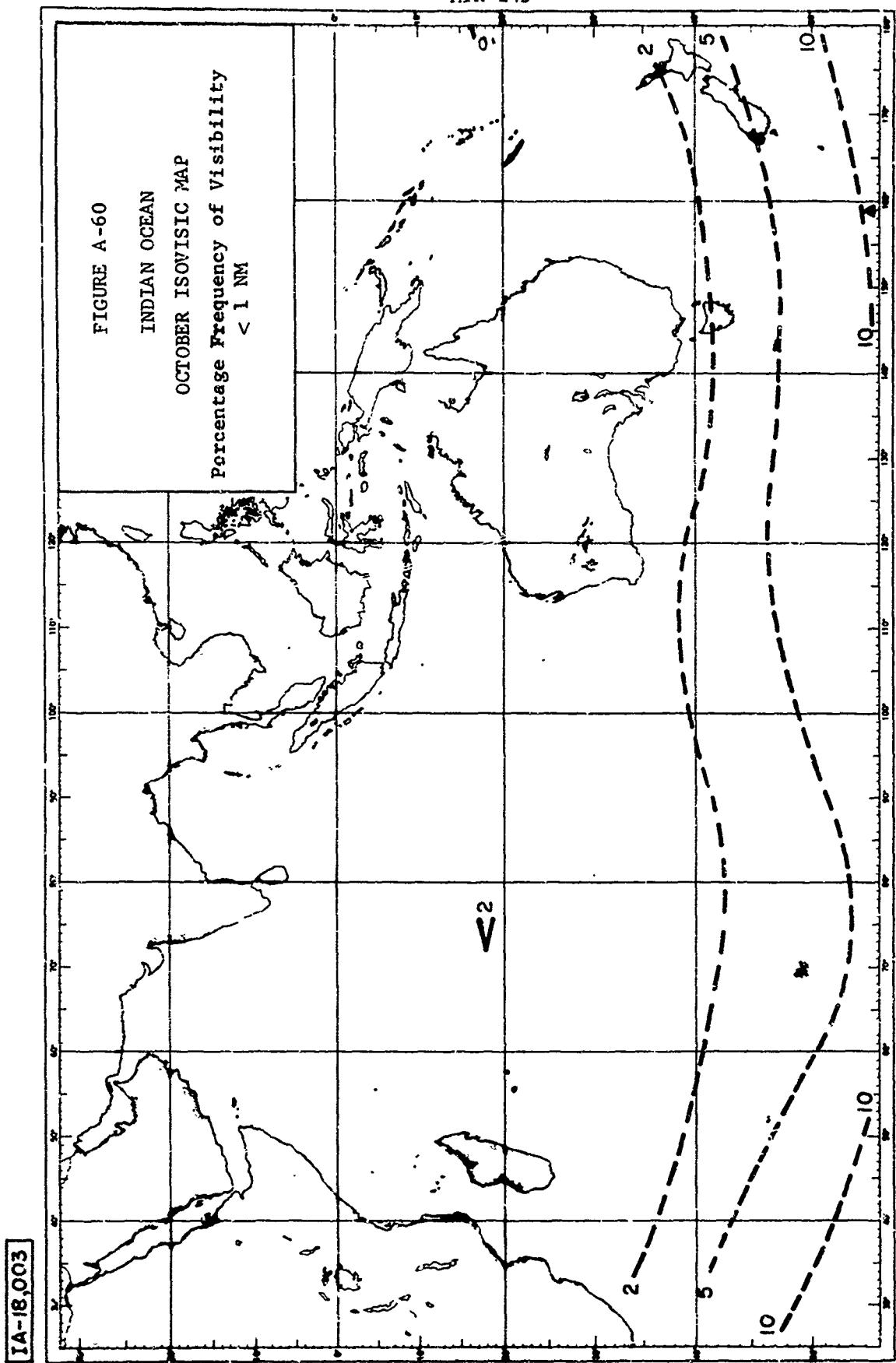
MTR-145



10004



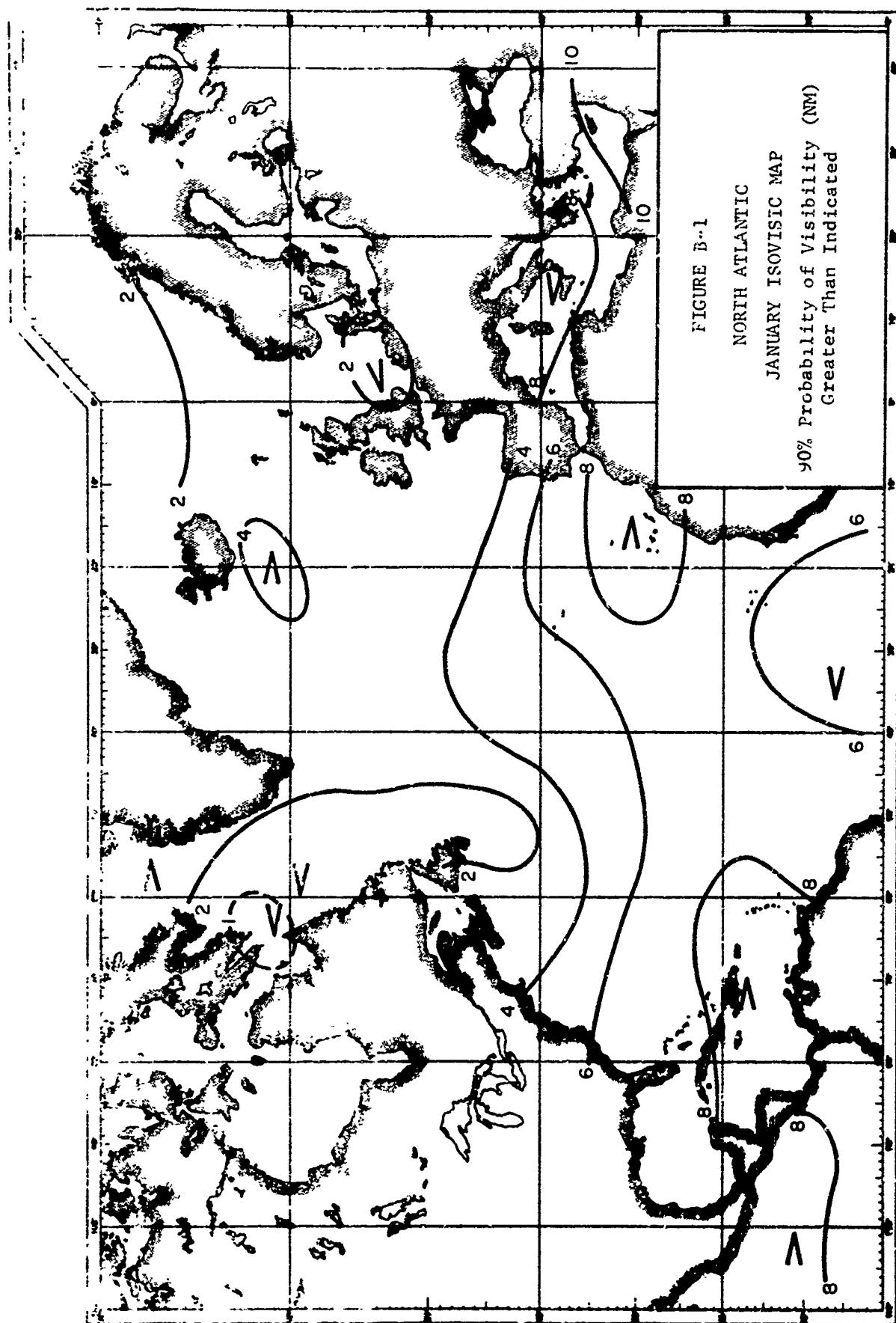
MTR-145



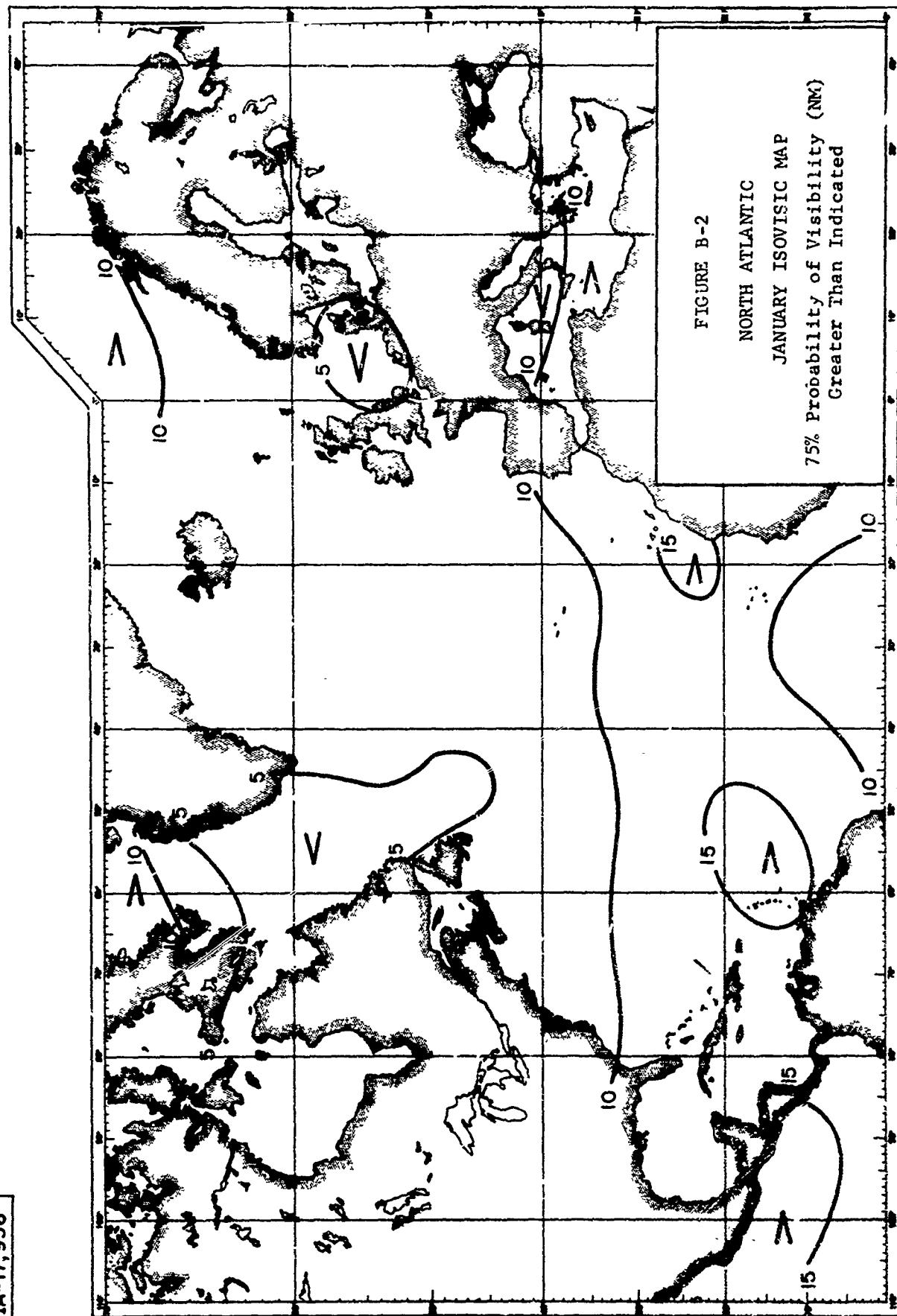
IA-18,003

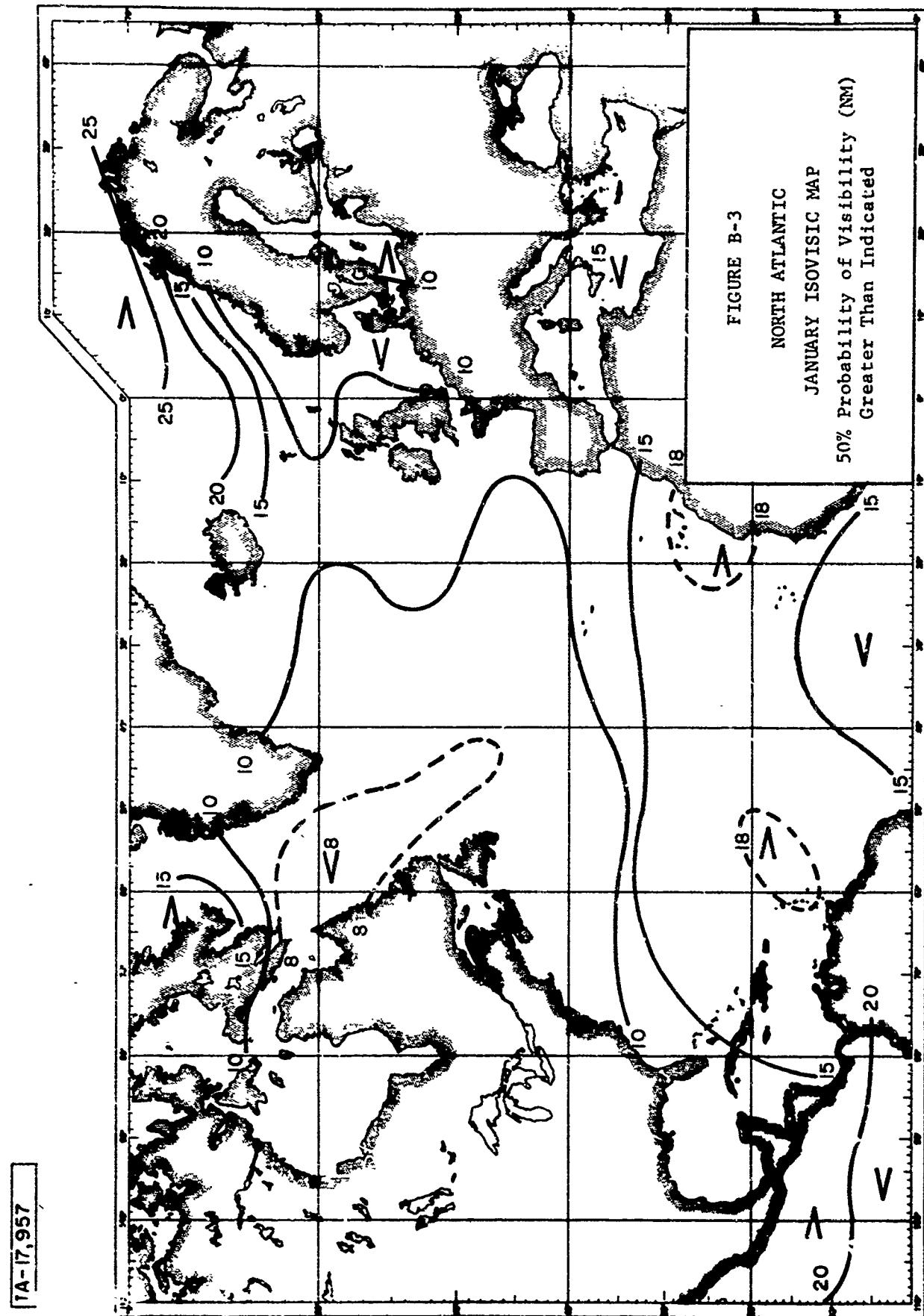
APPENDIX B

**ISOVISIC MAPS - 90 PERCENT, 75 PERCENT, 50 PERCENT AND
25 PERCENT PROBABILITY OF VISIBILITY GREATER THAN INDICATED**

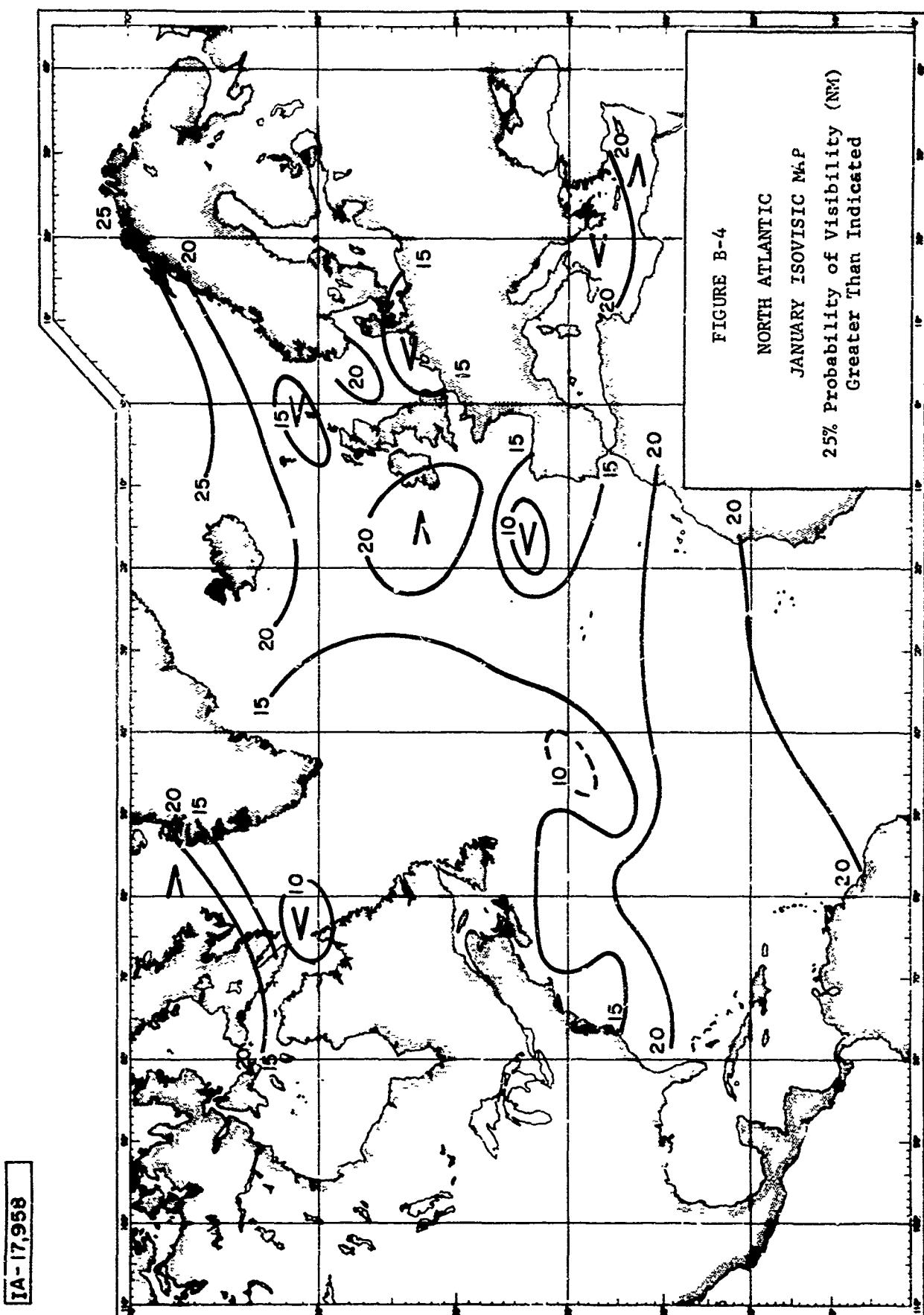


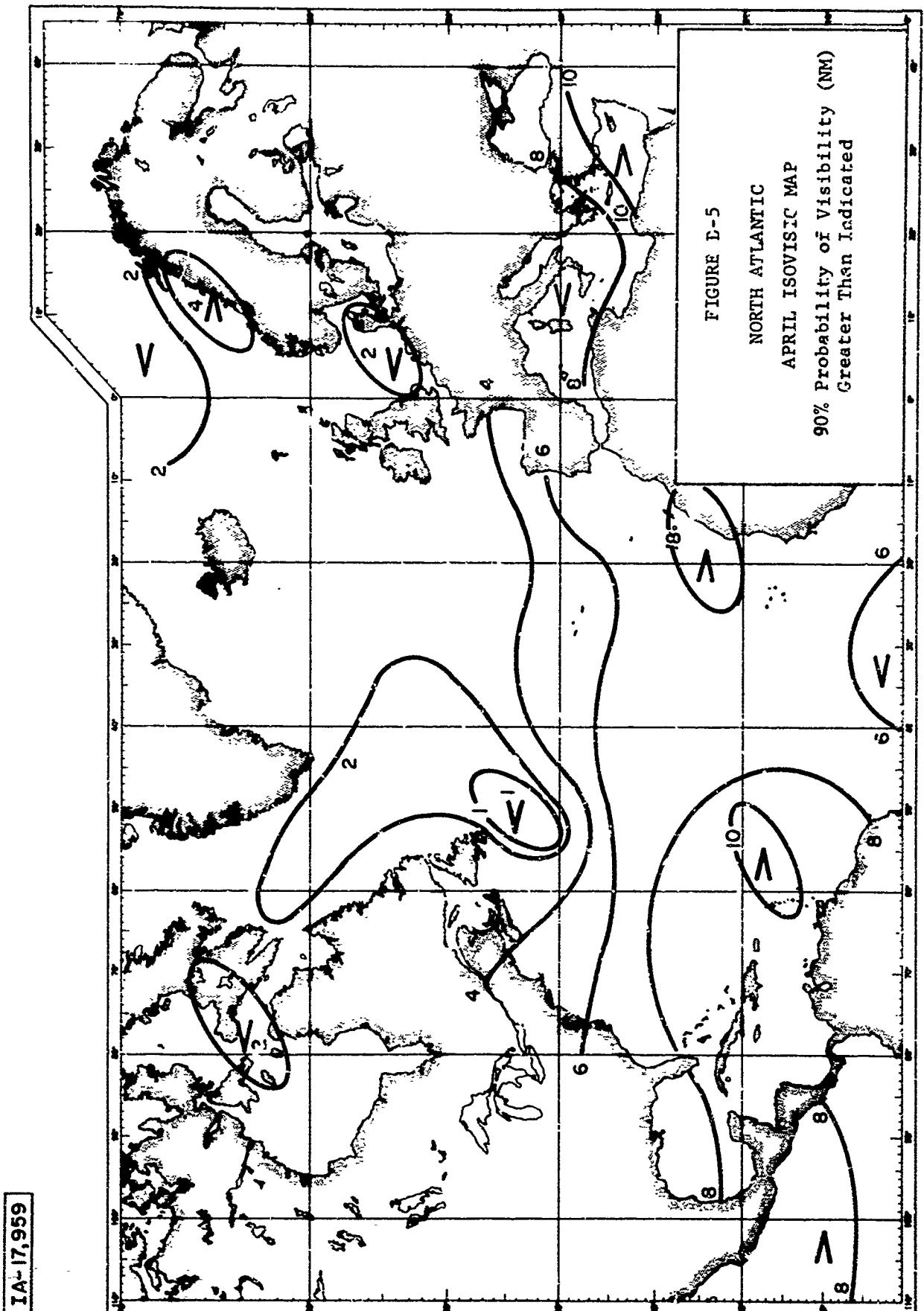
IA-17, 956



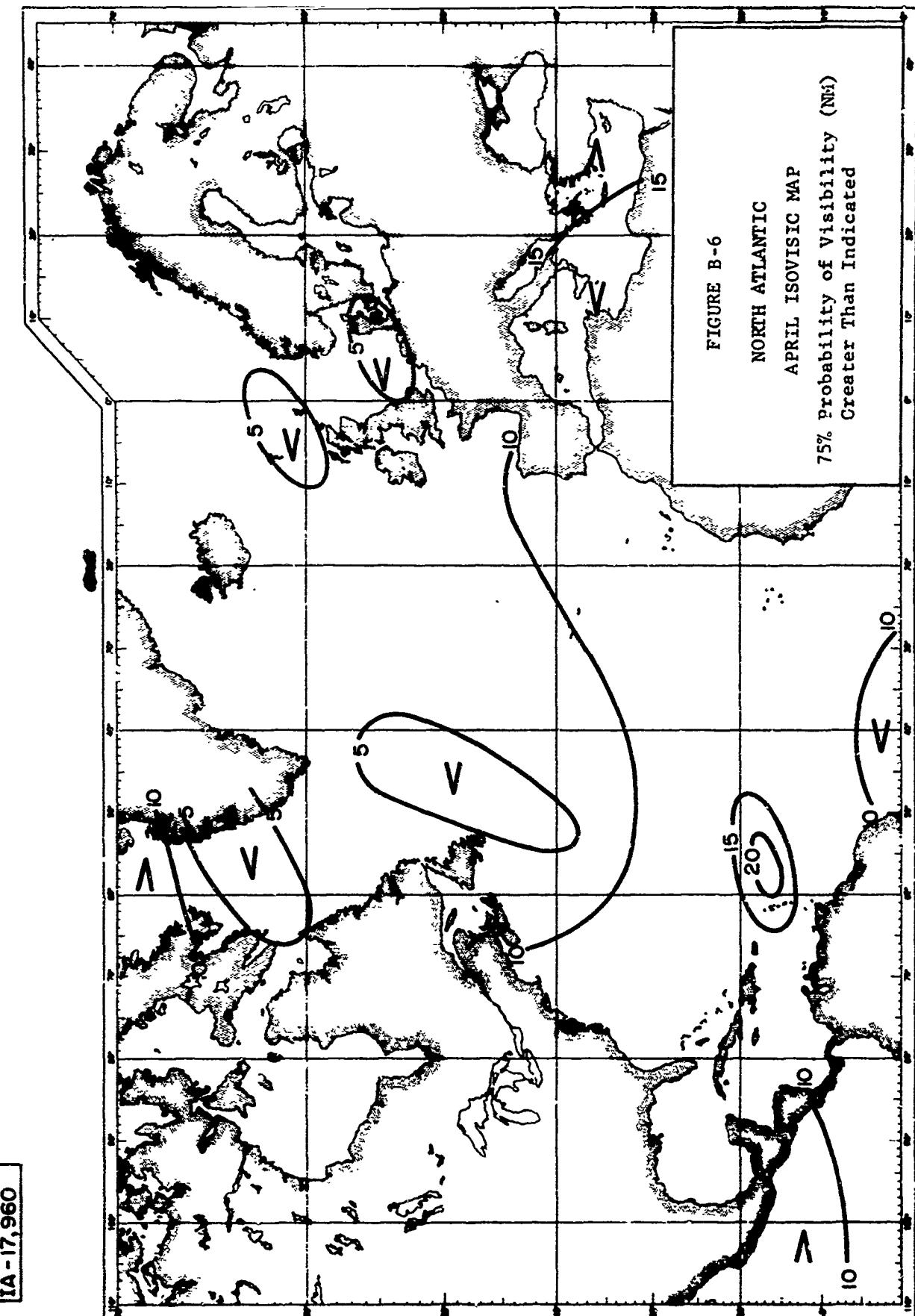


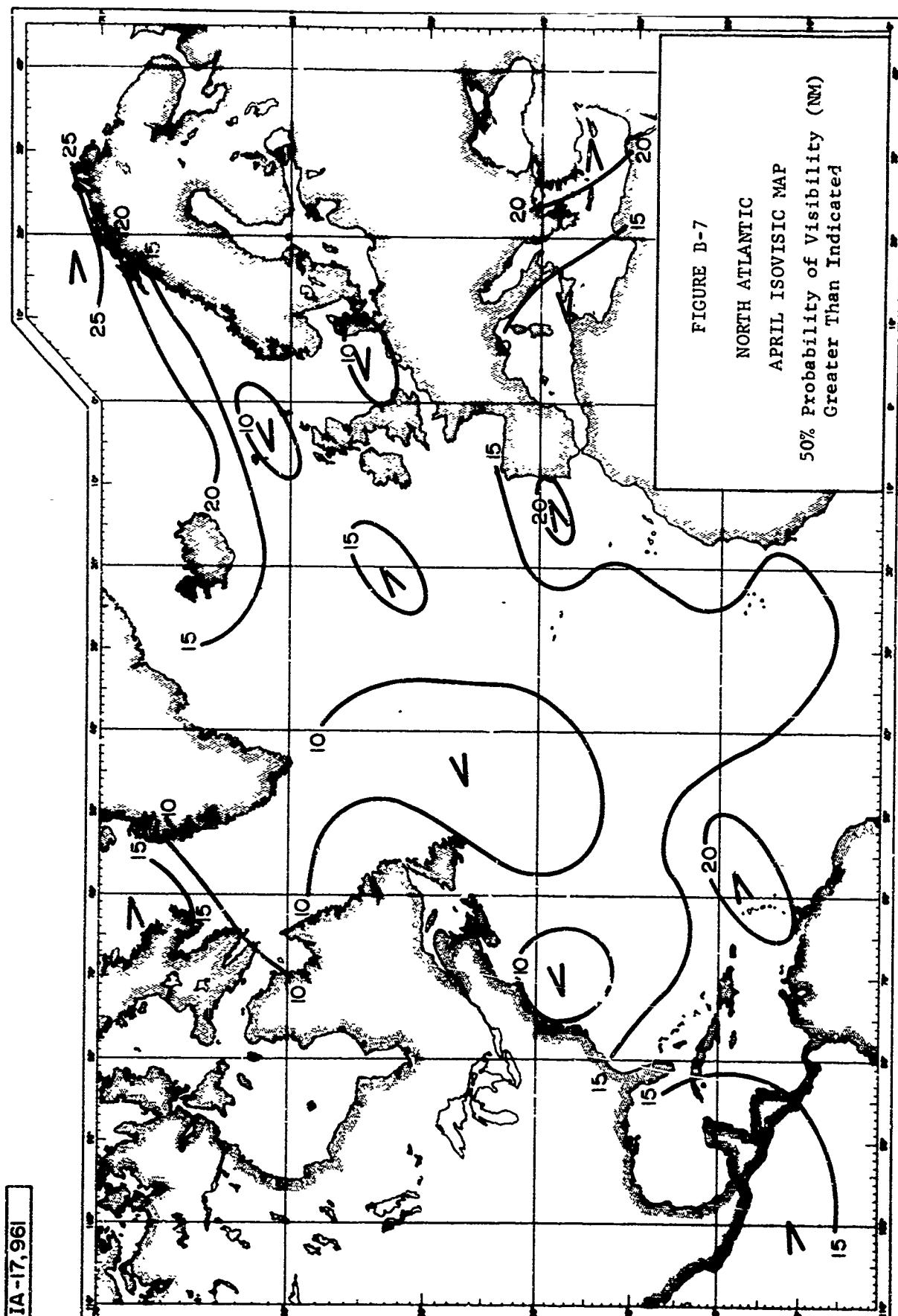
MTR-145





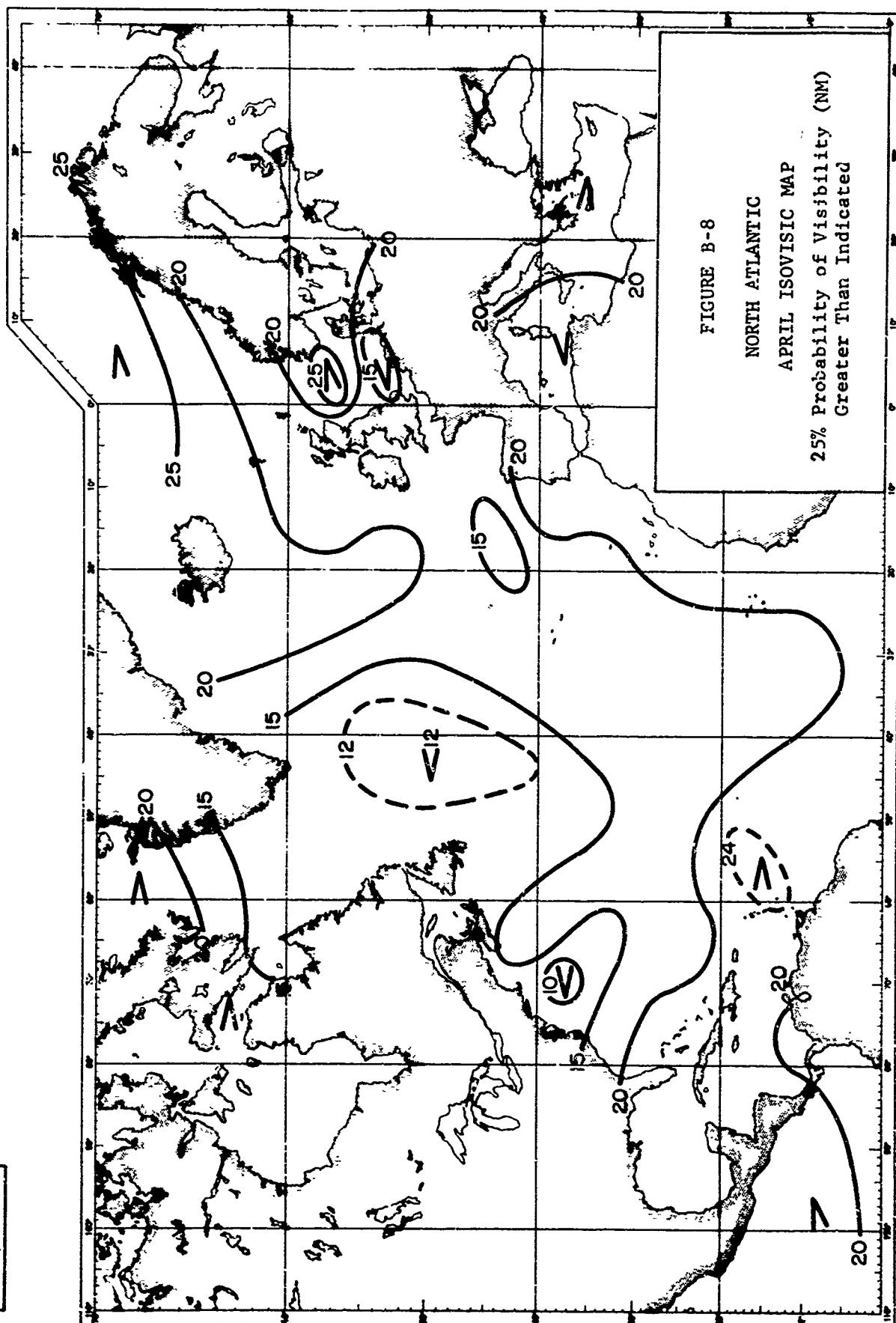
MTR-145





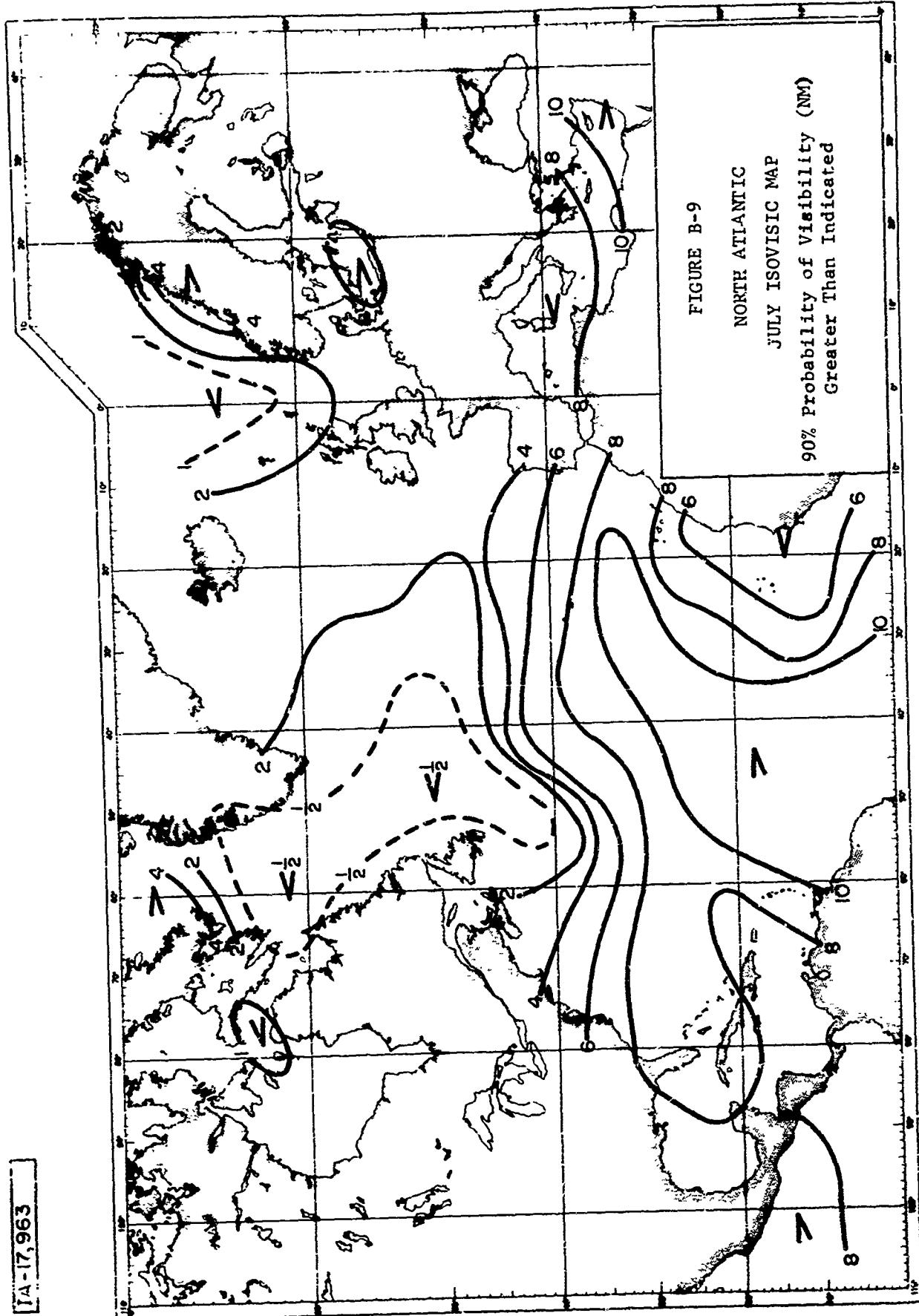
IA-17,961

MTR-145

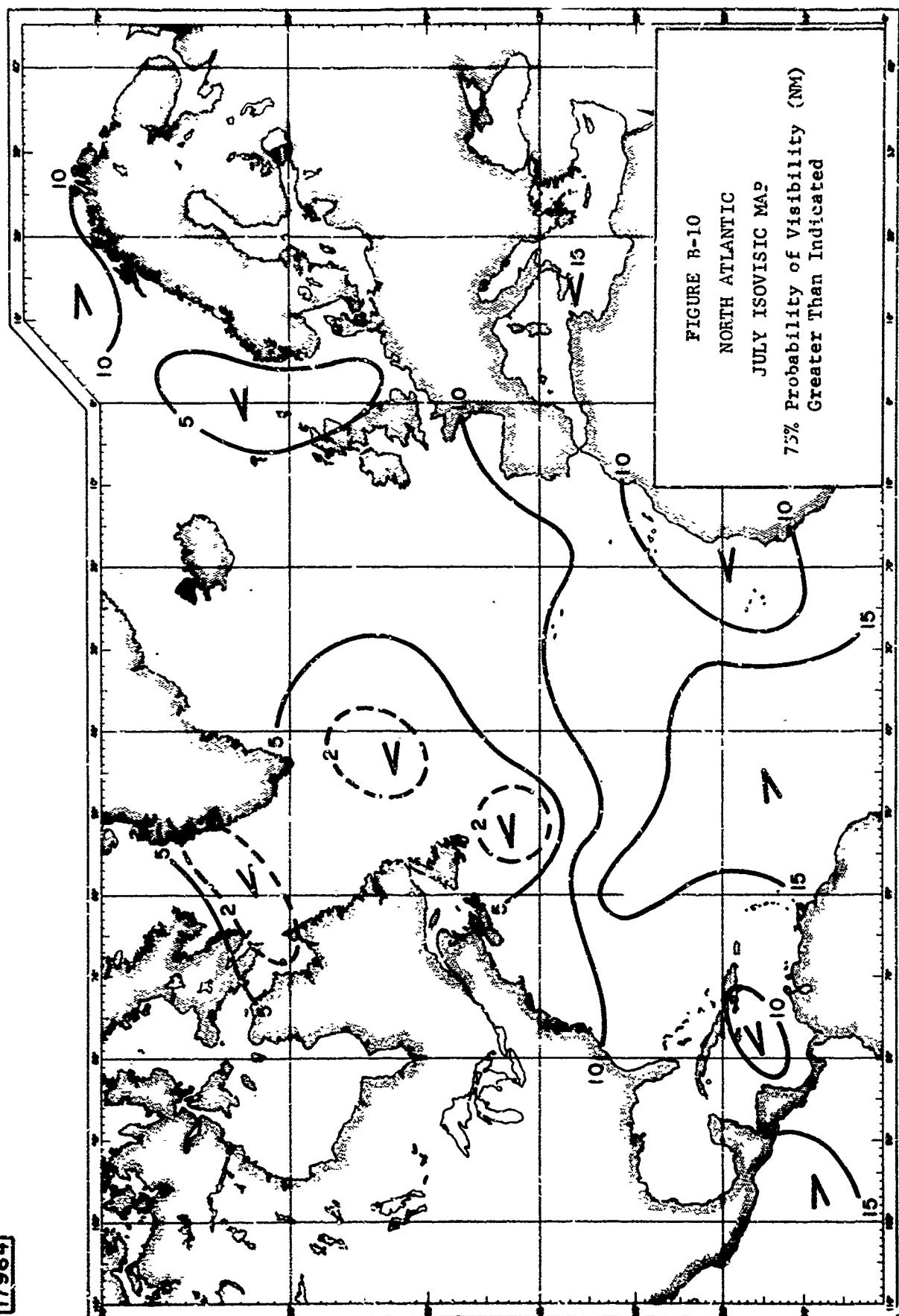


TA-17,962

MTR-145



MTR-145



MTR-145

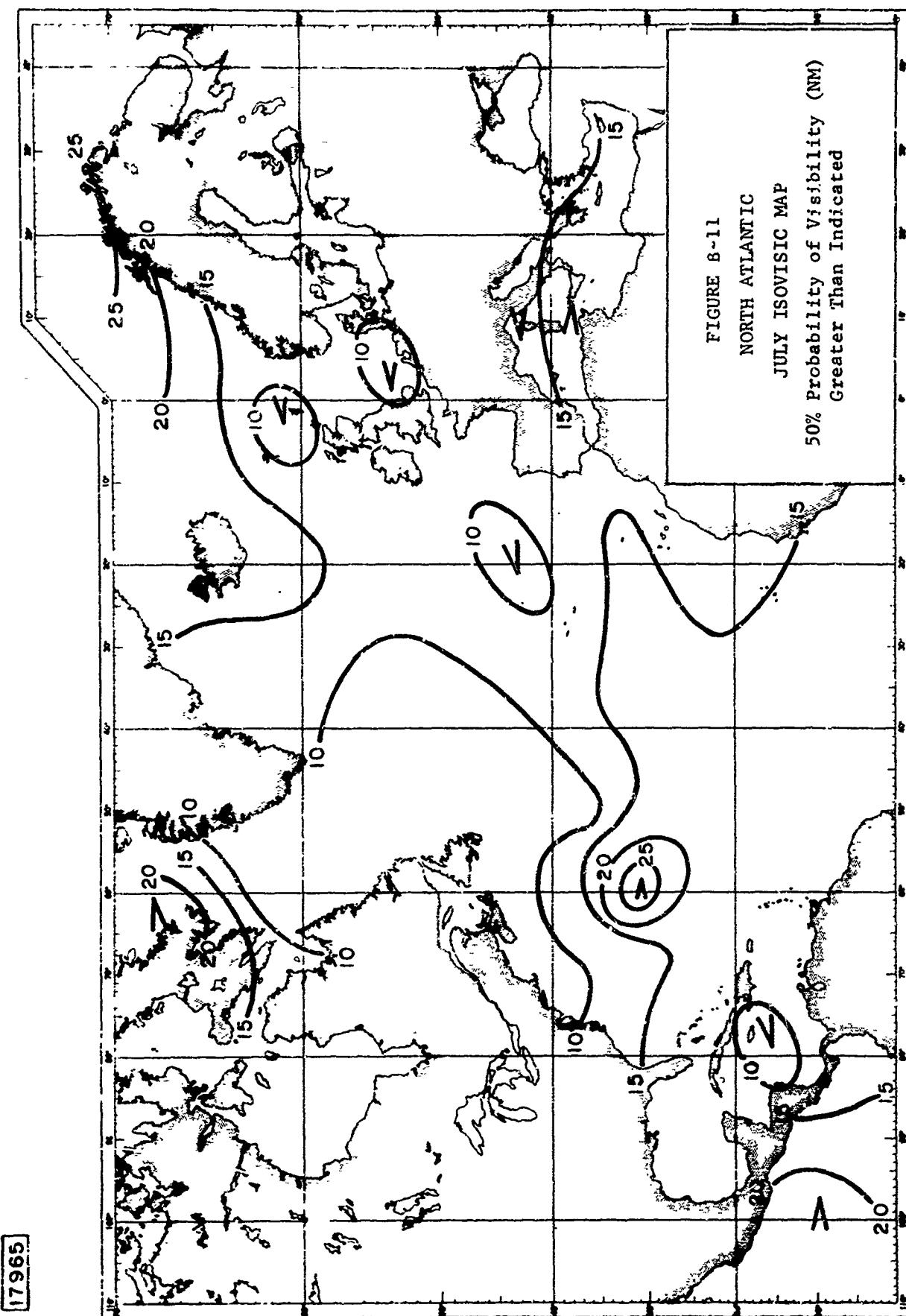
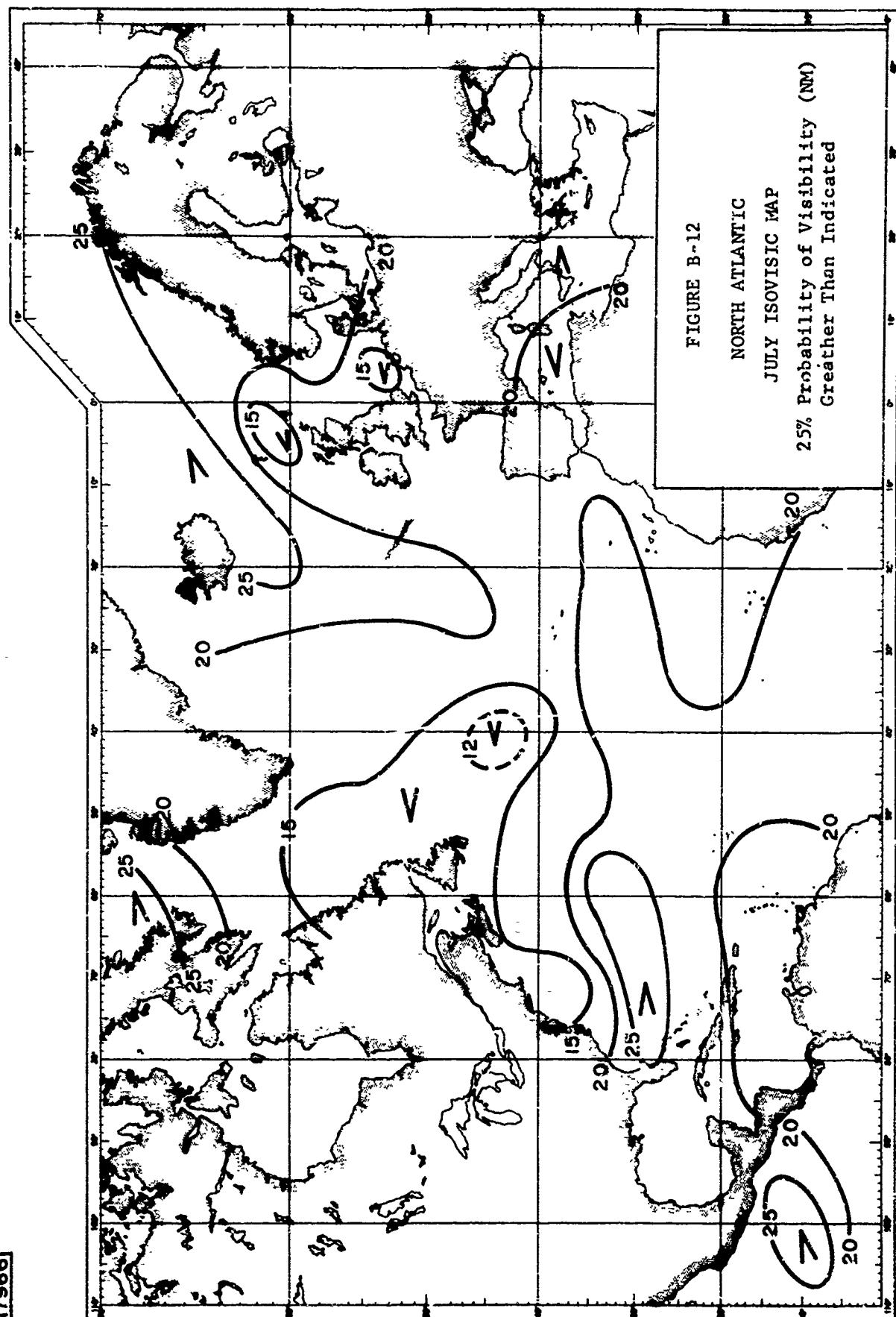


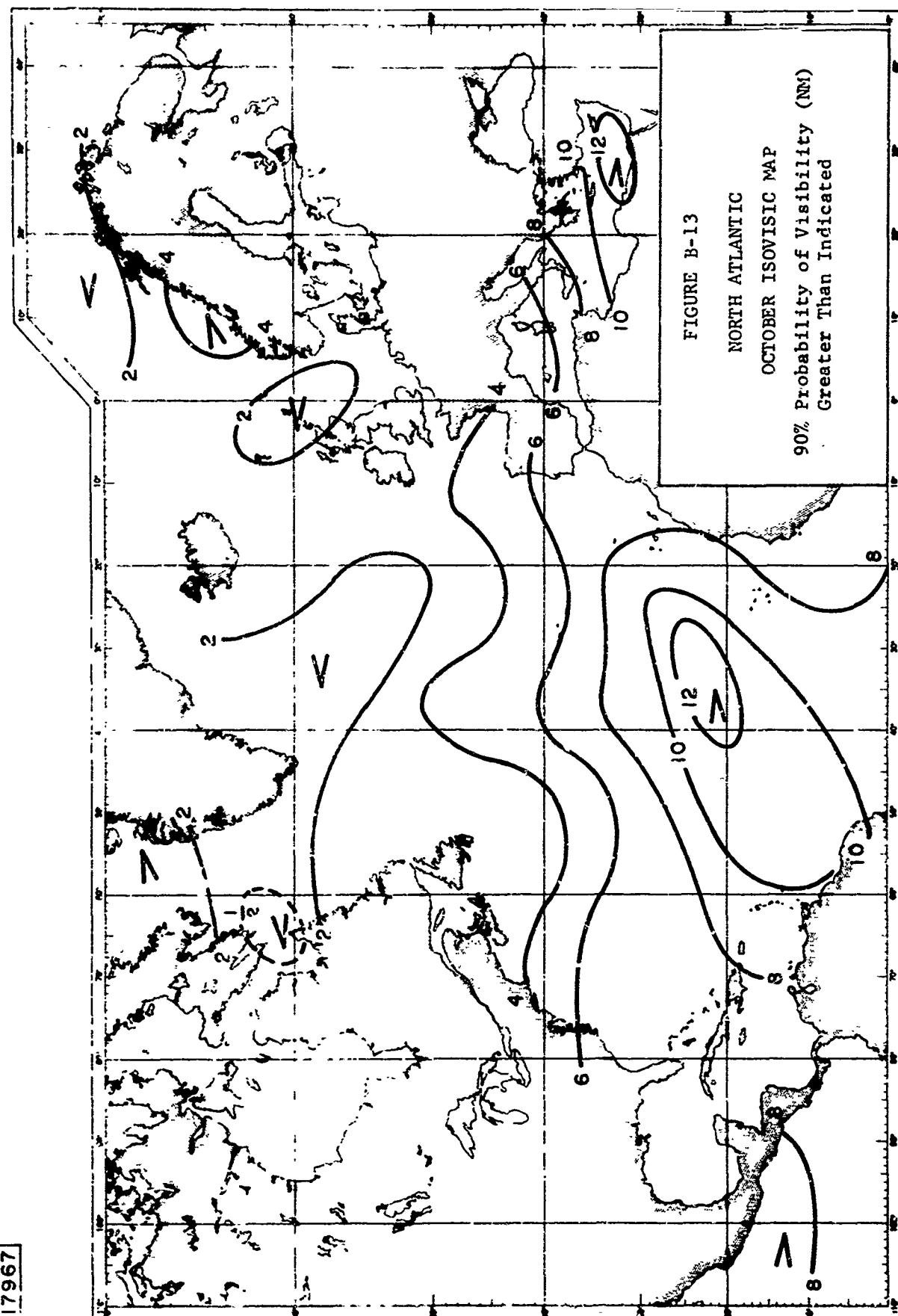
FIGURE B-11
NORTH ATLANTIC
JULY ISOVISTIC MAP
50% Probability of Visibility (NM)
Greater Than Indicated

17965

B-12

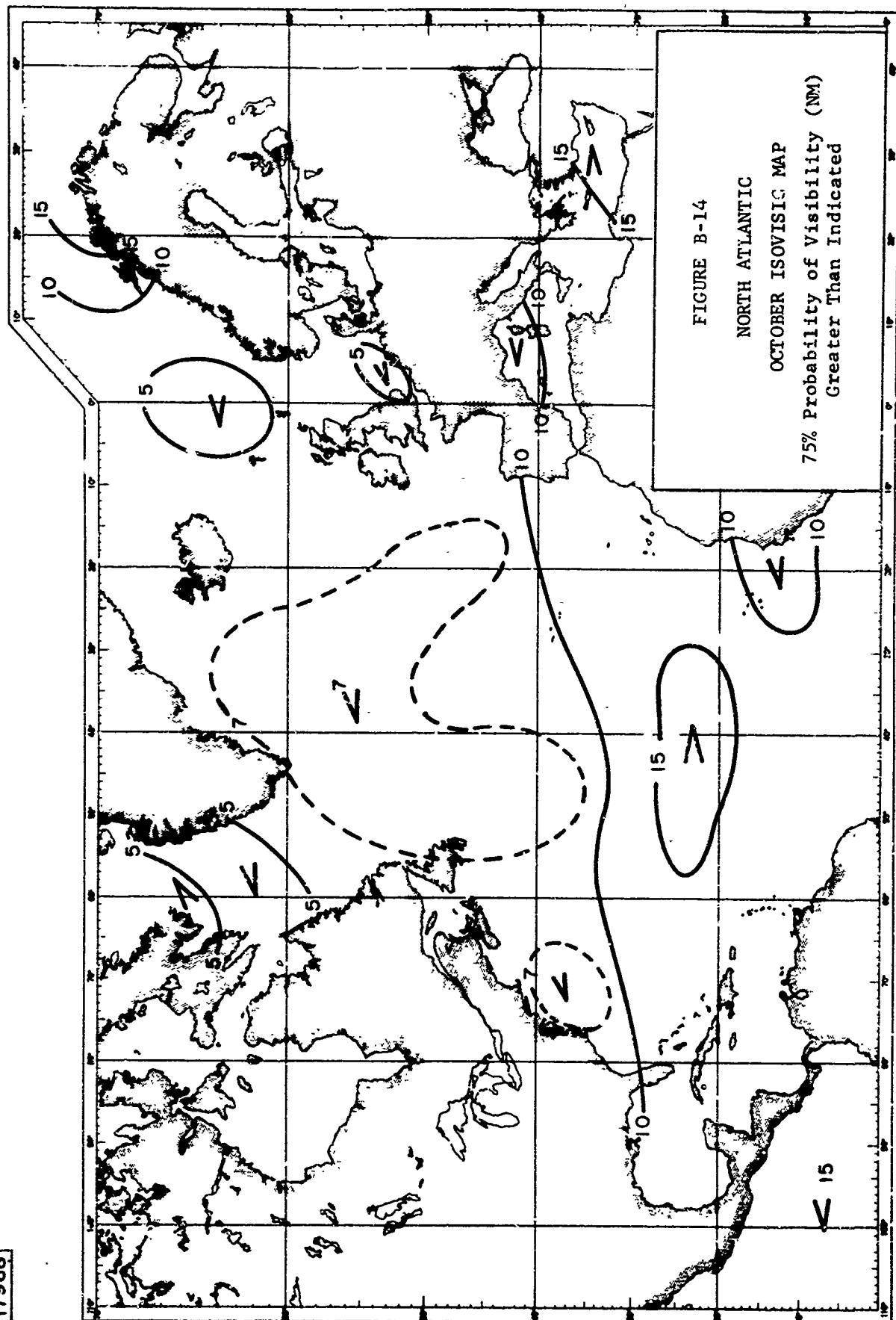


1966



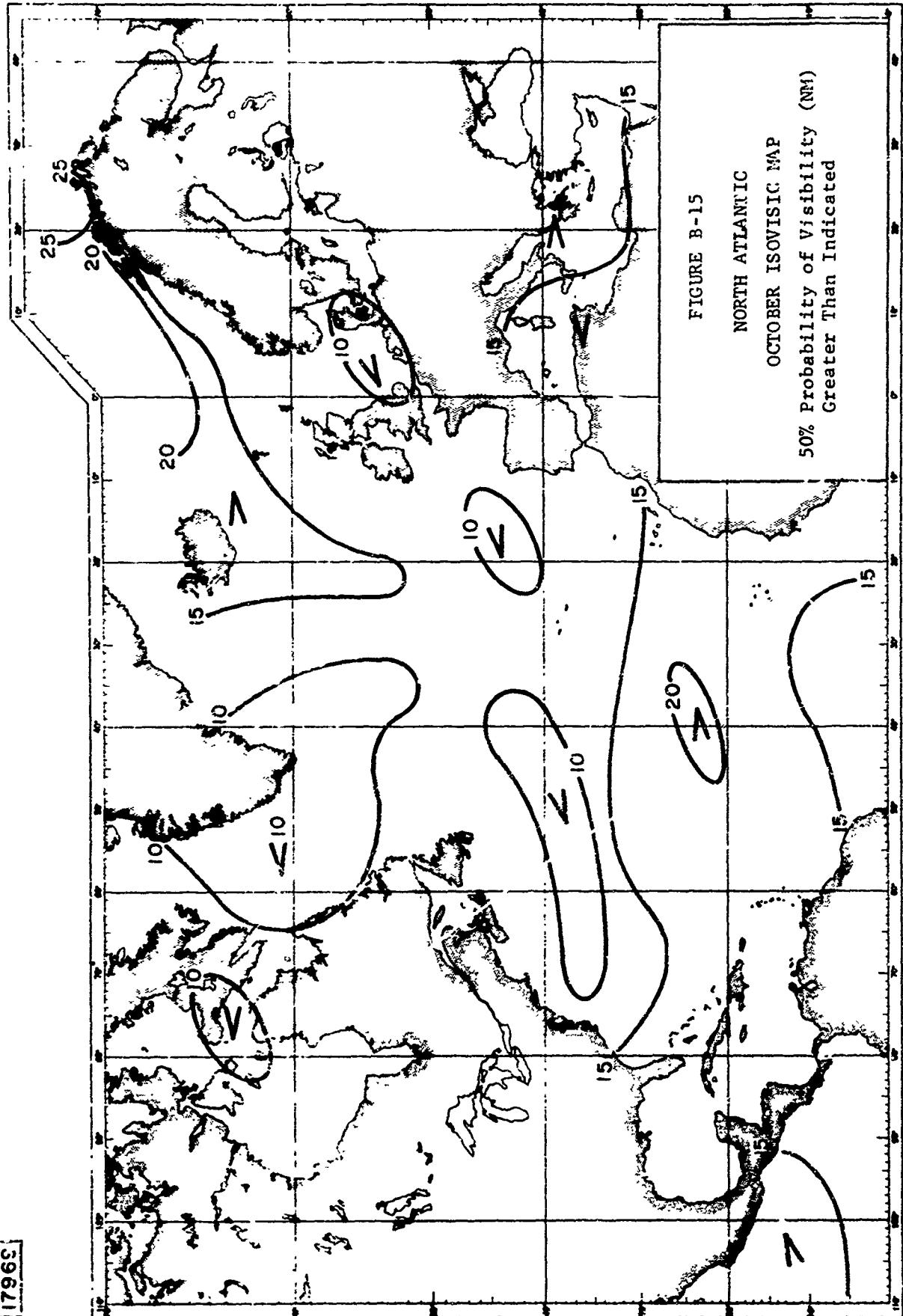
17967

MTR-145



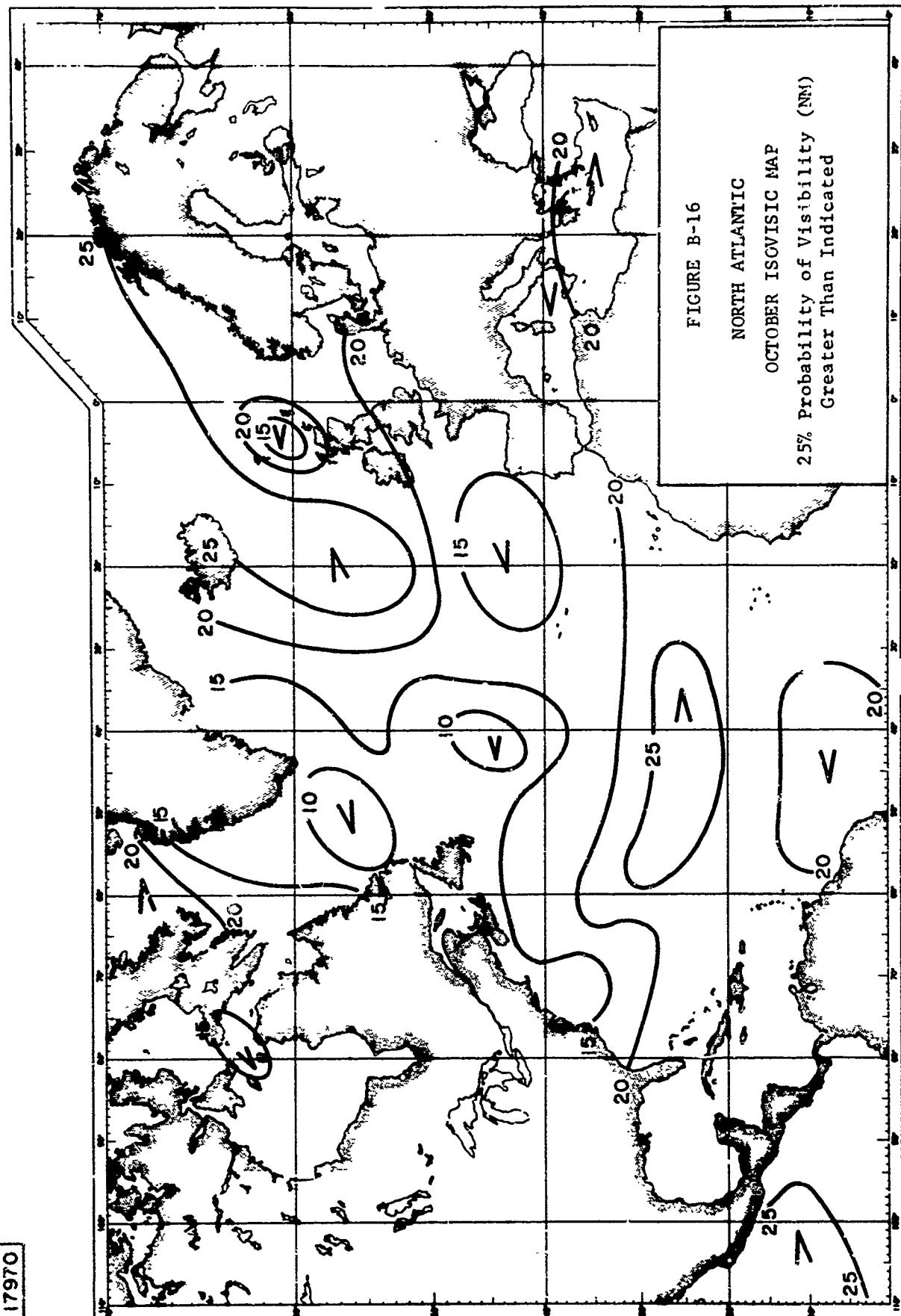
17968

MTR-145

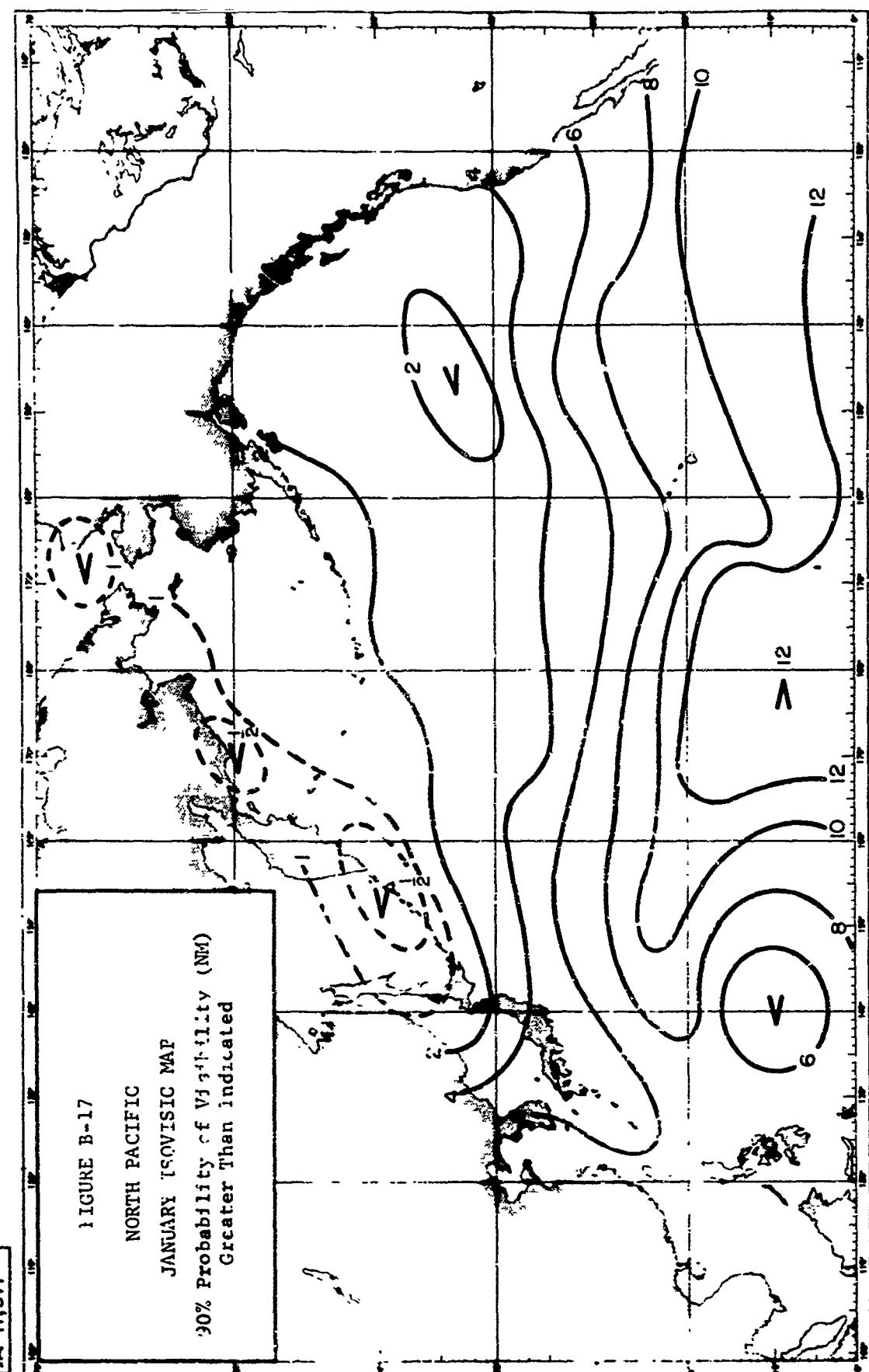


17965

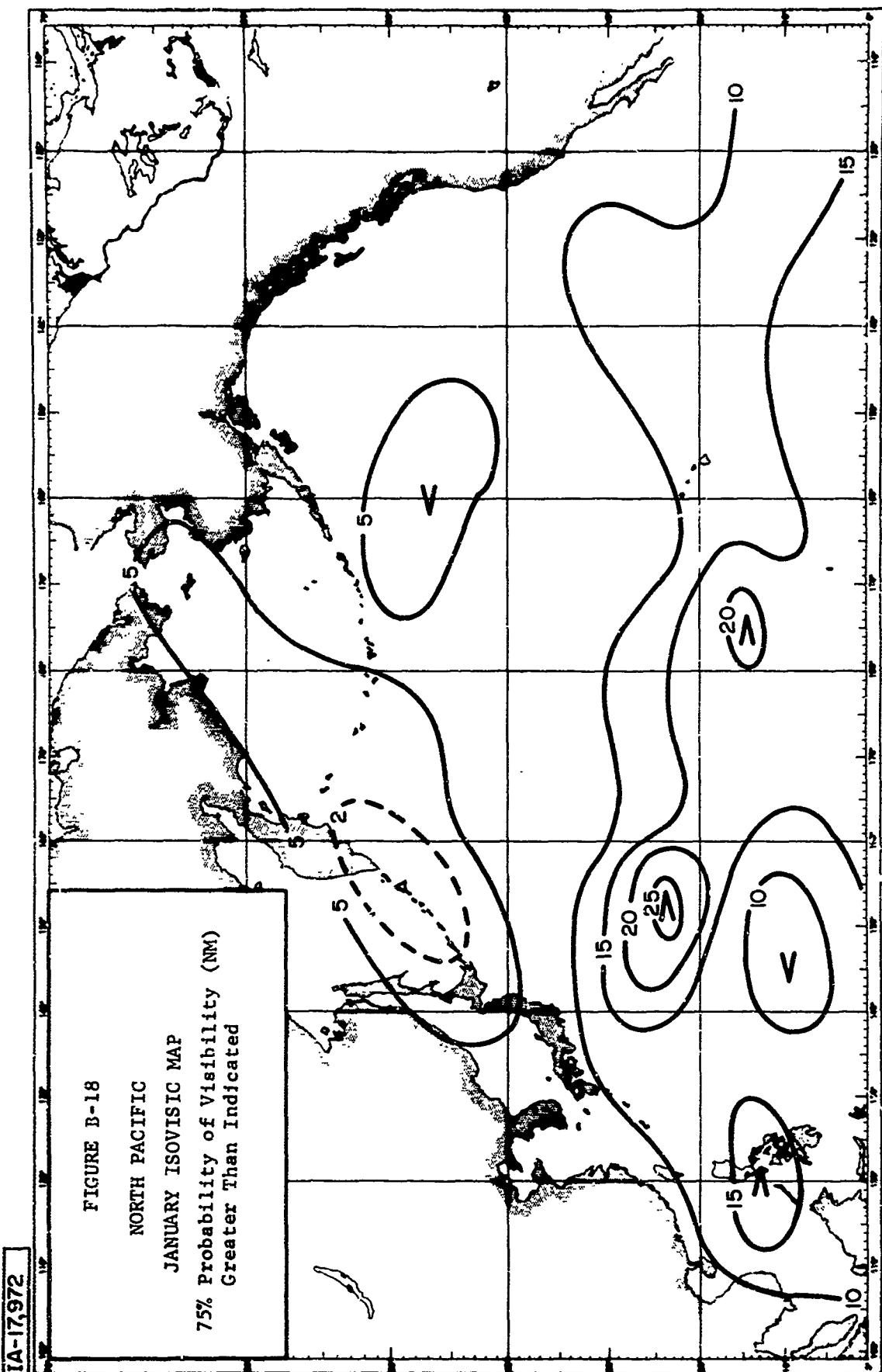
MTR-145



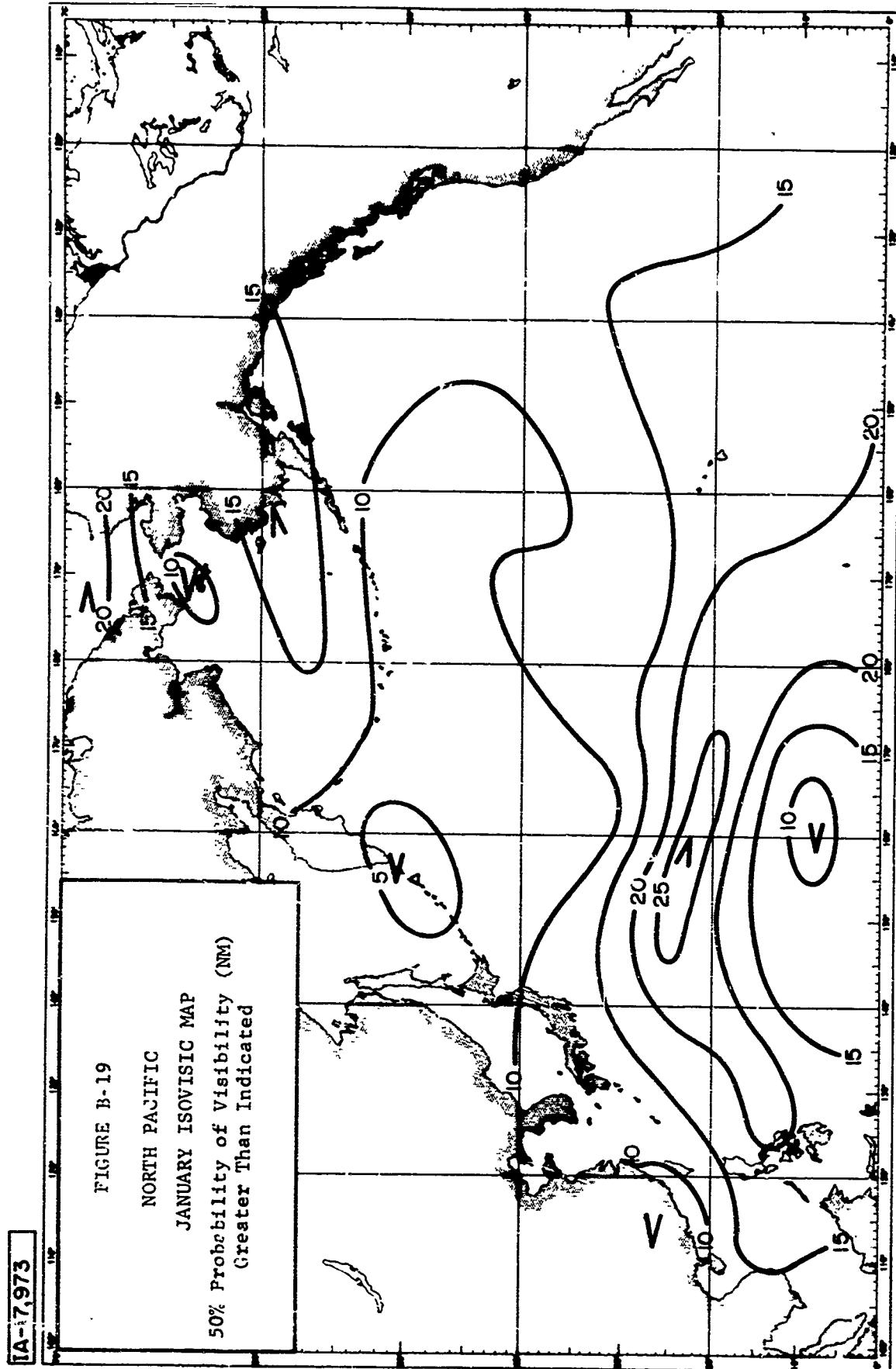
IA-17,971



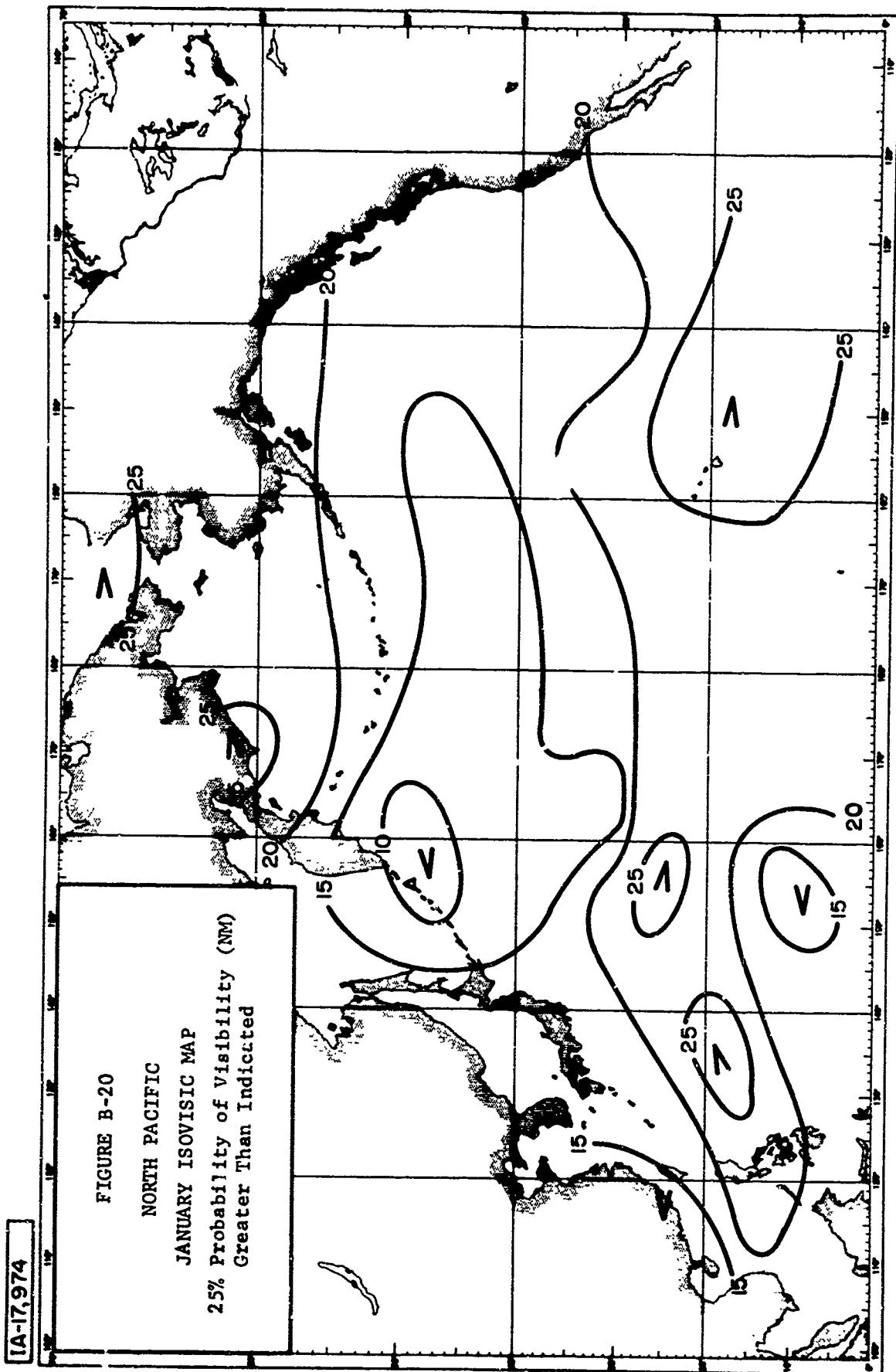
MIR-145



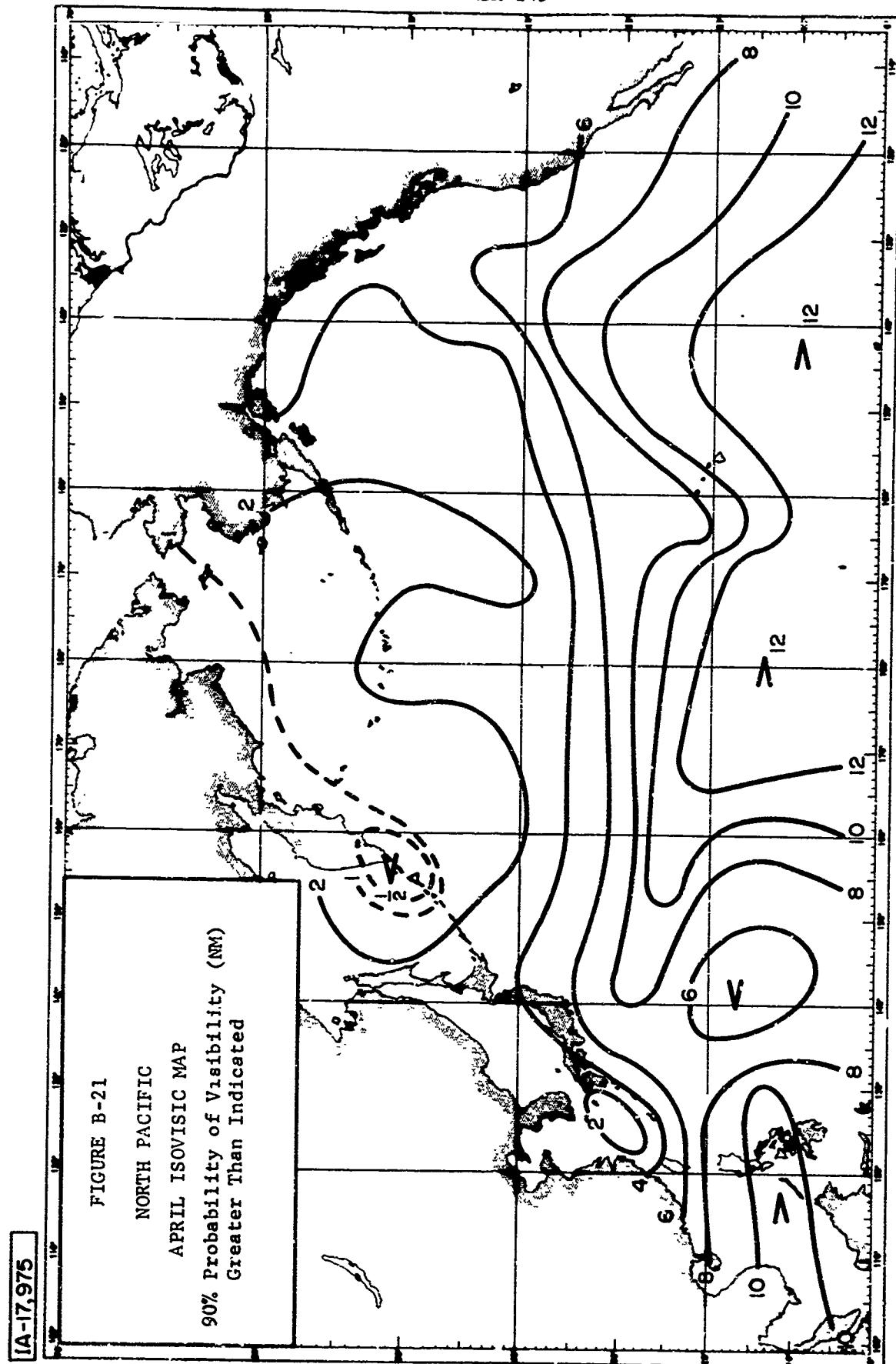
MTR-145



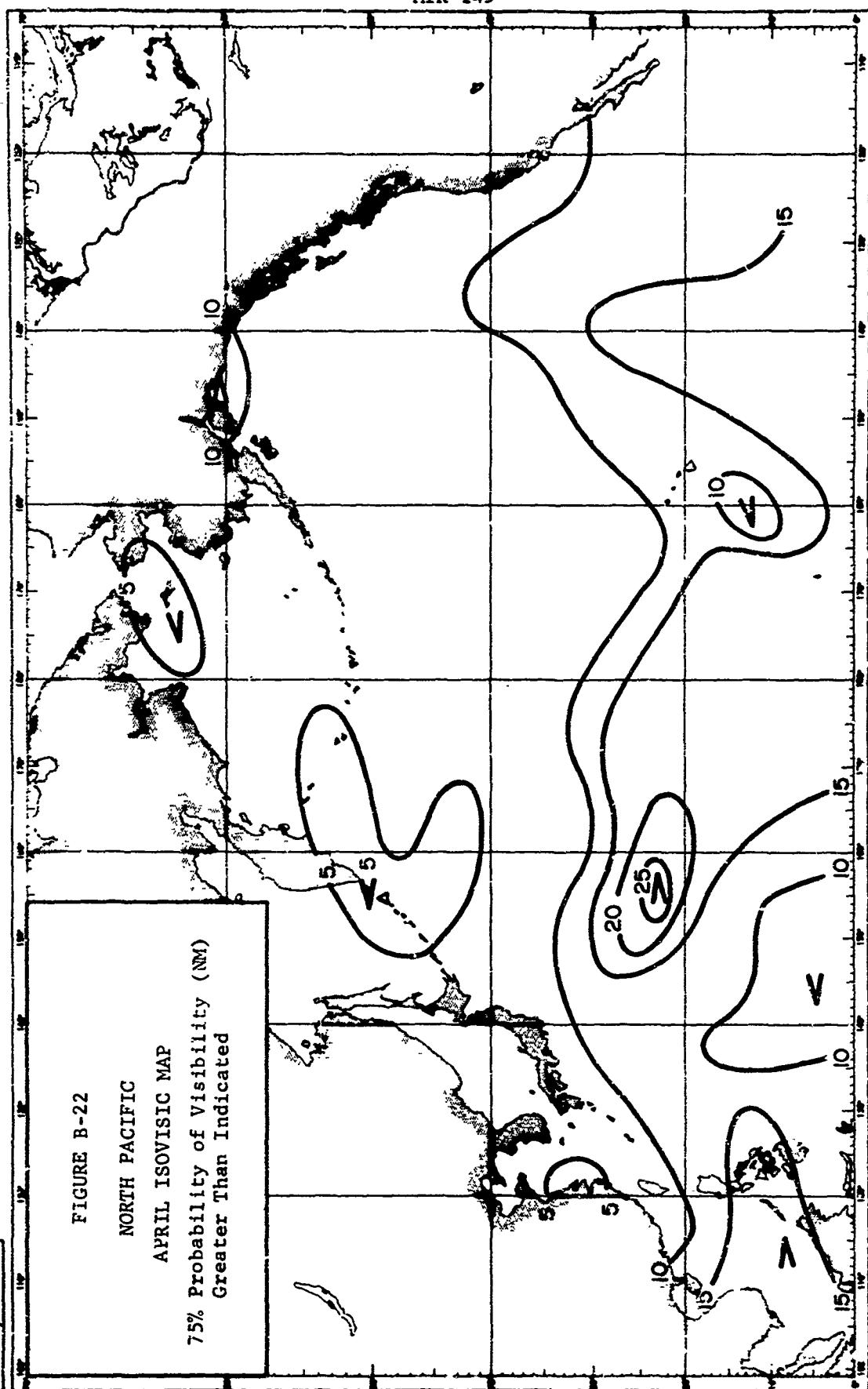
MTK-145



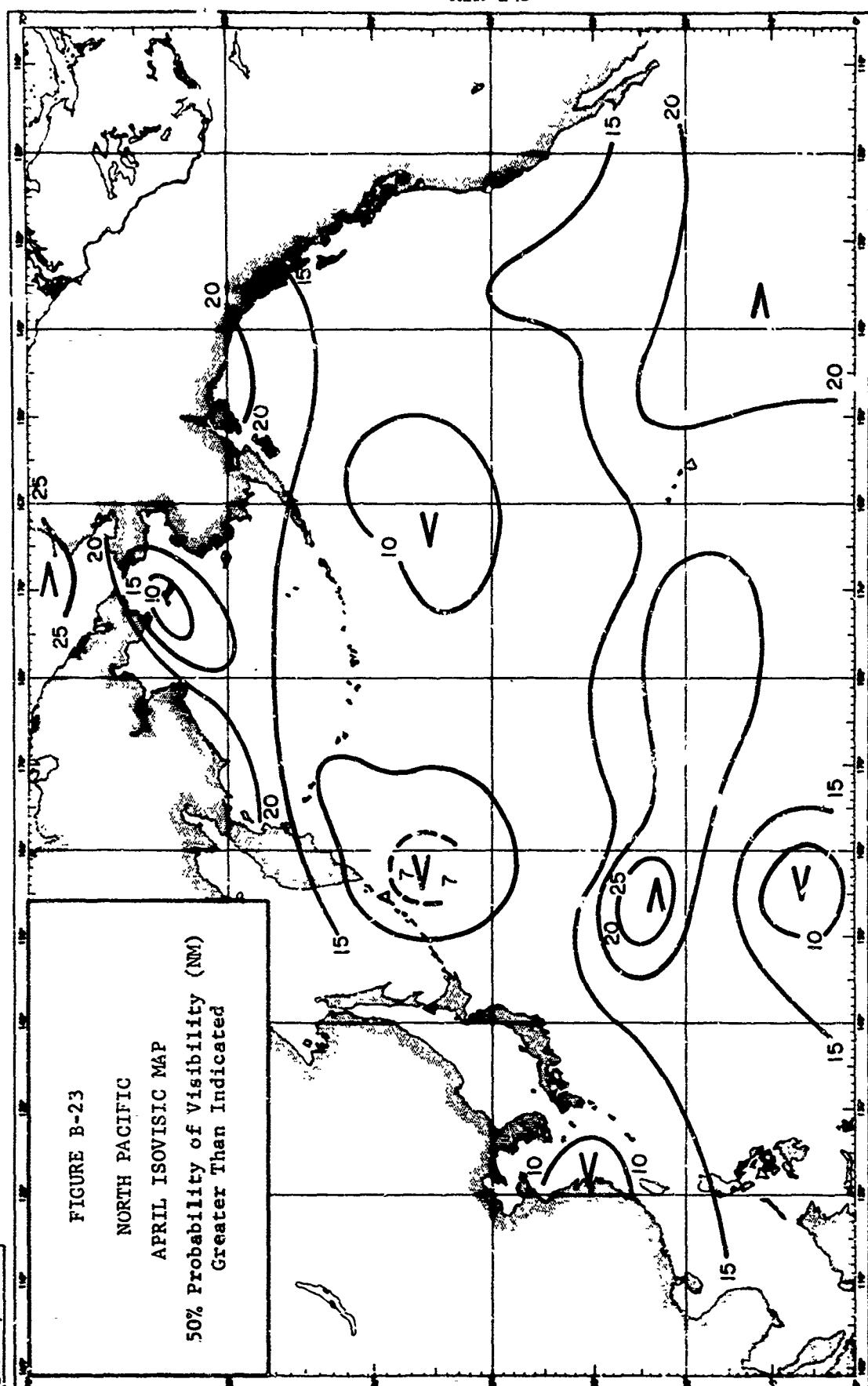
MTR-145



IA-17-976

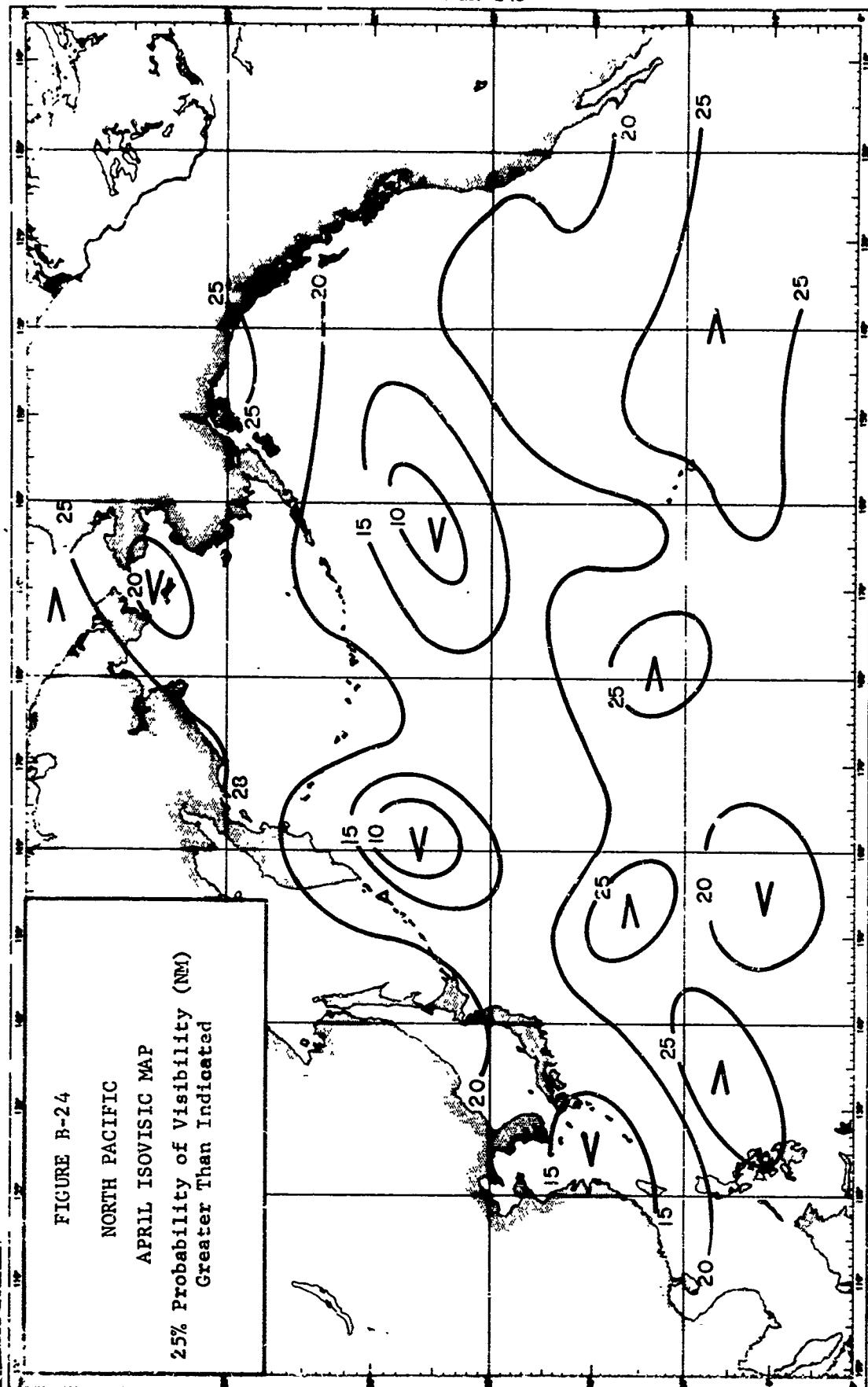


MTD = 145

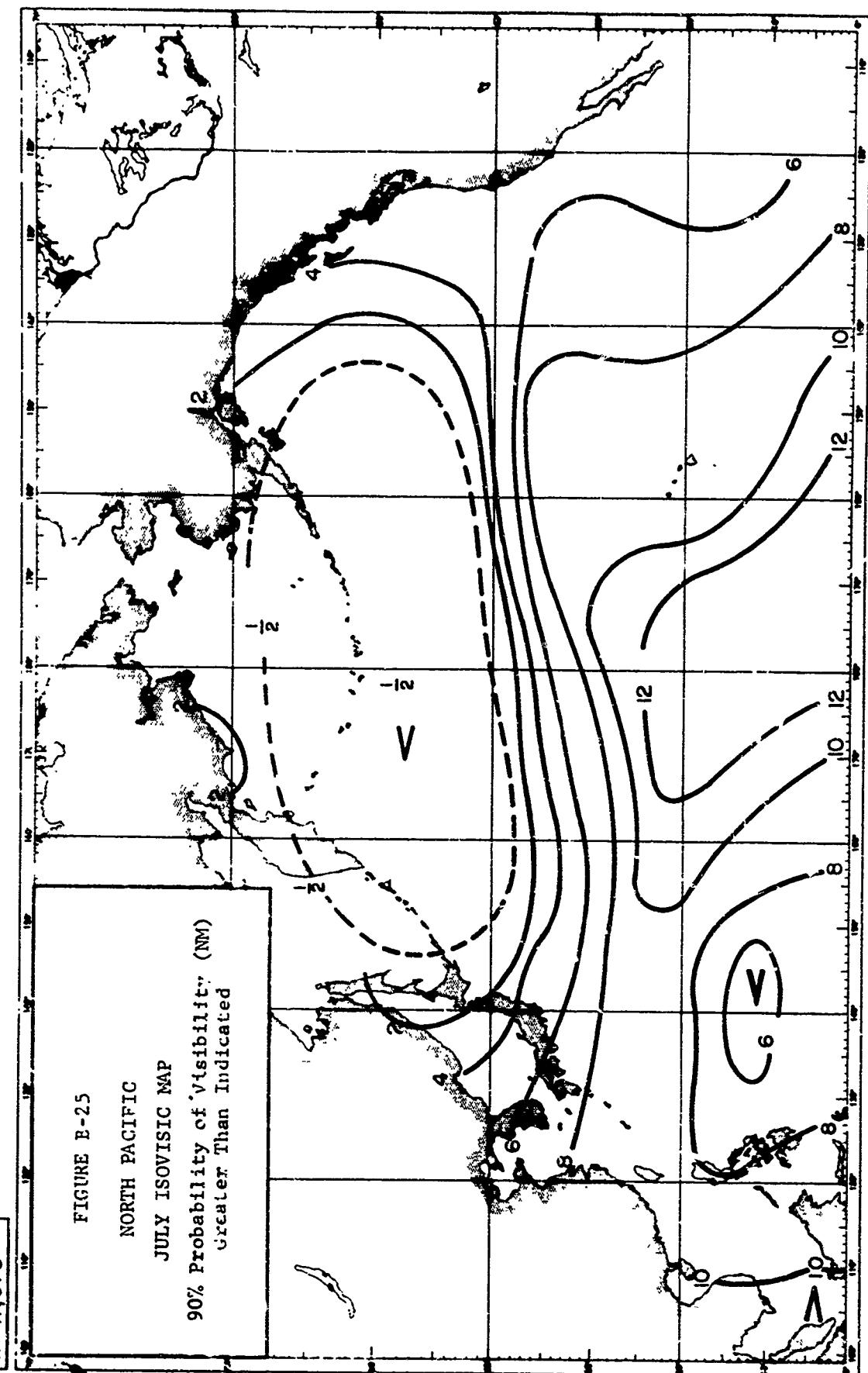


216-21-01

IA-17 978



MTR-145



IA-17,979

FIGURE E-25

NORTH PACIFIC

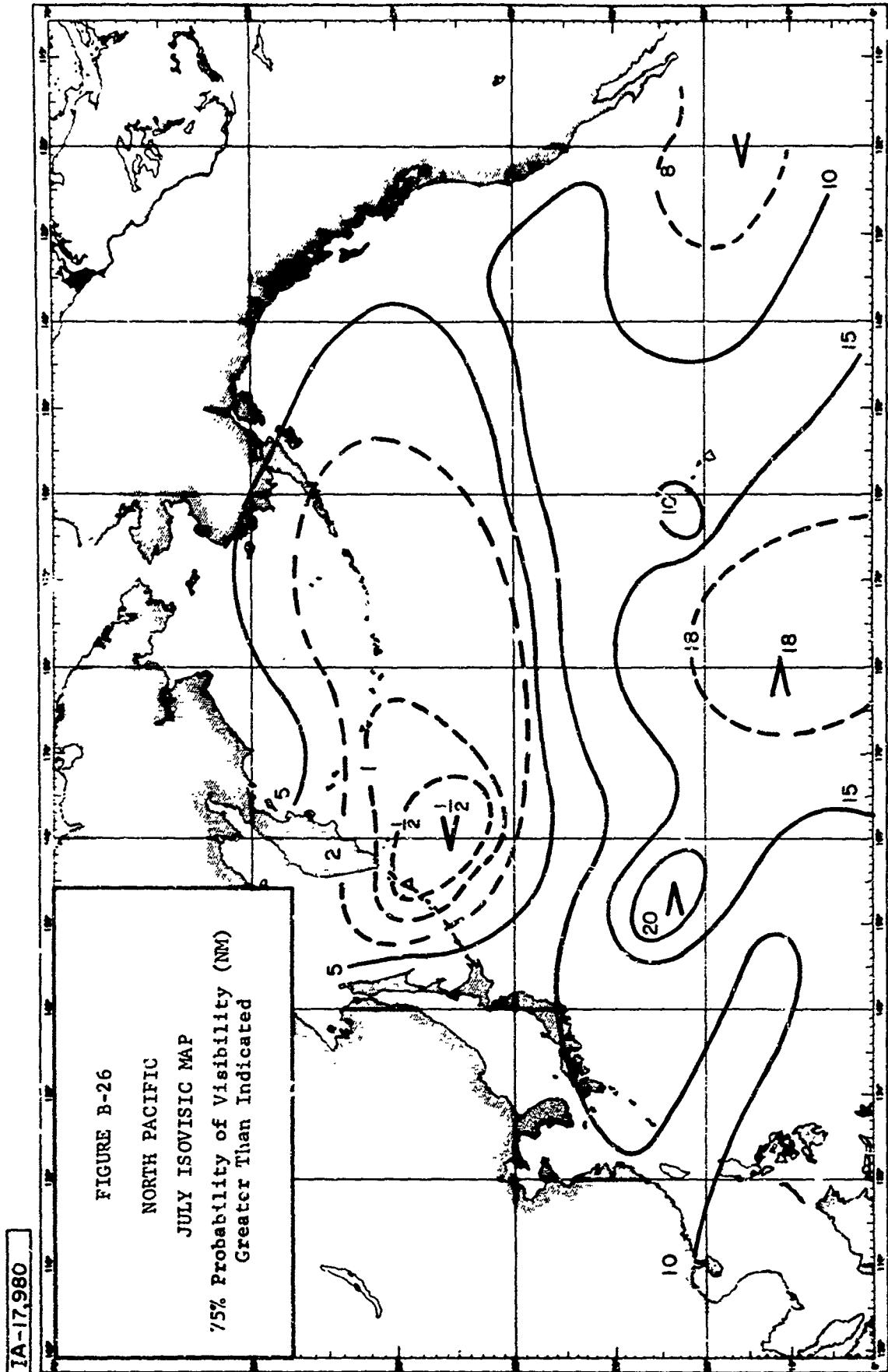
JULY ISOVISIC MAP

90% Probability of "Visibility" (NM)

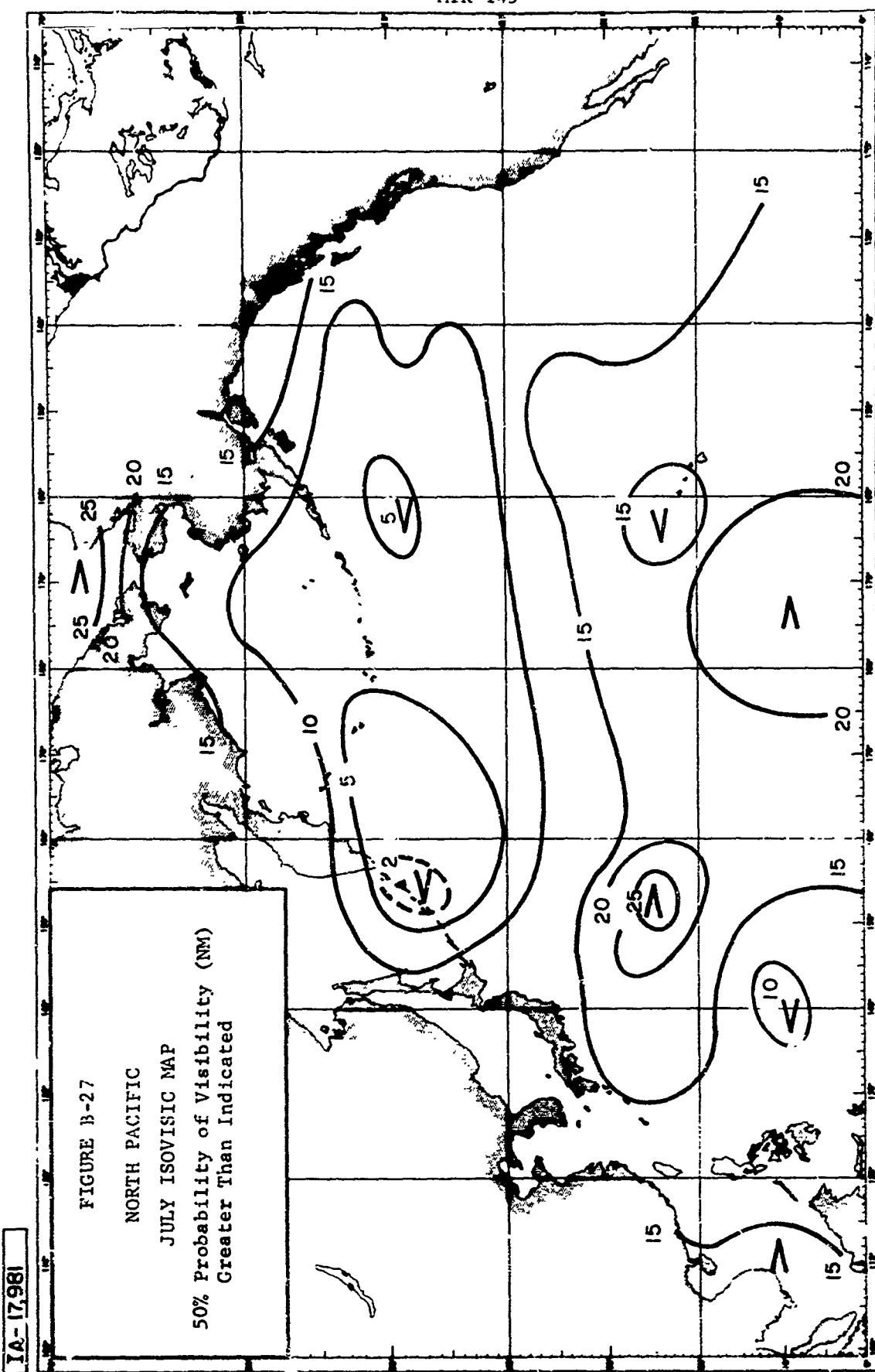
Greater Than Indicated

B-26

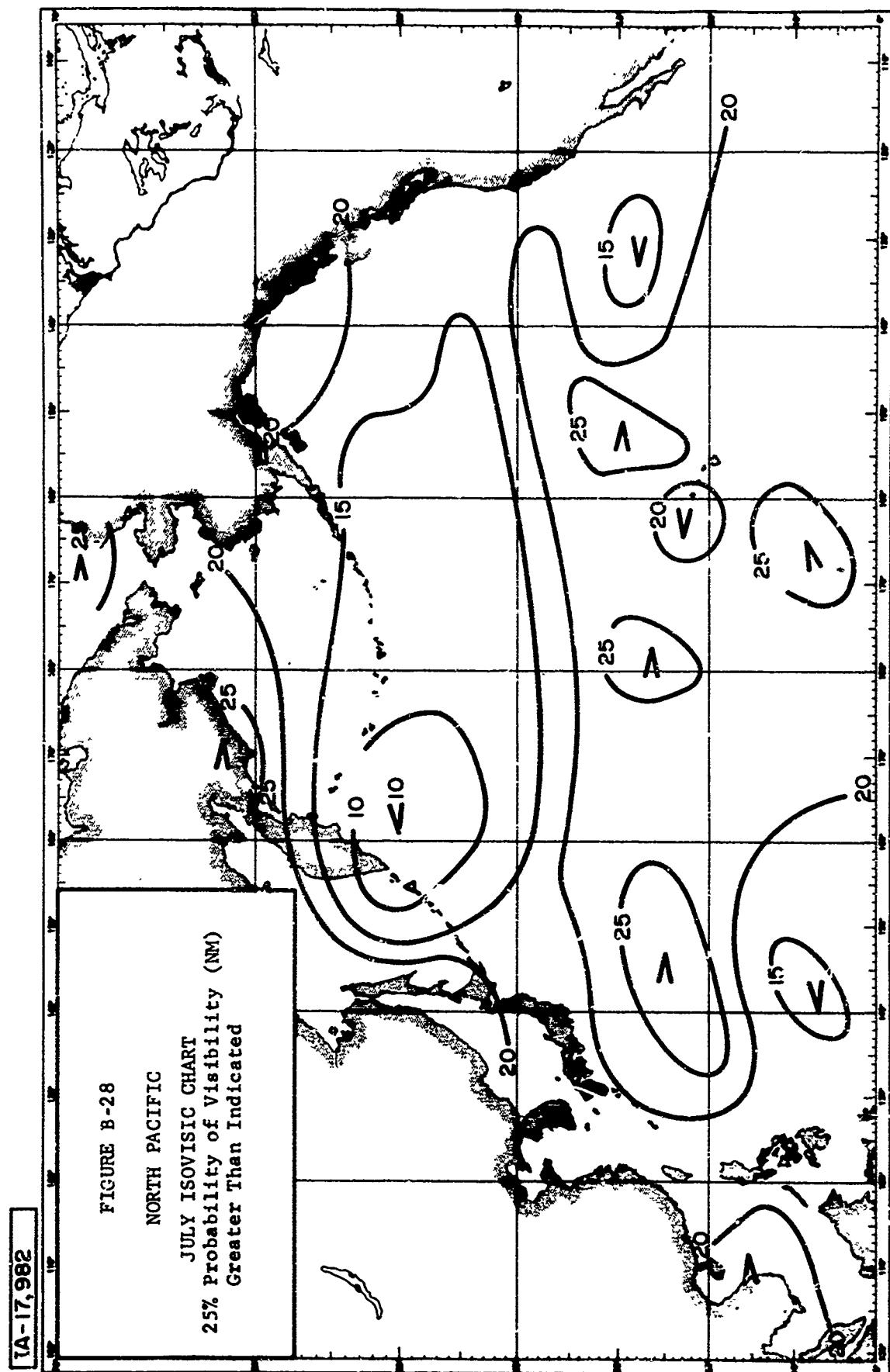
MTR-145



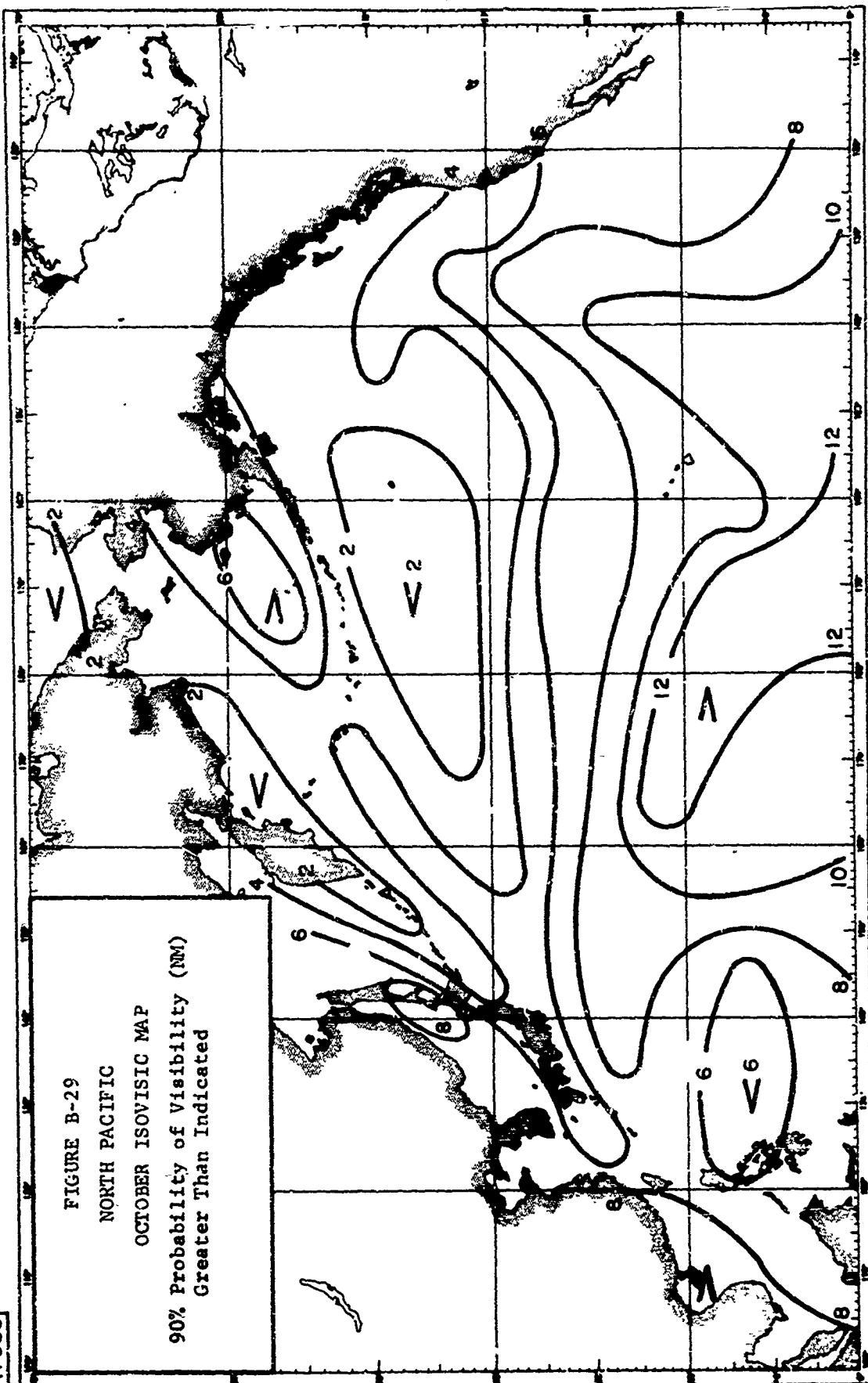
MTR-145



MTR-145

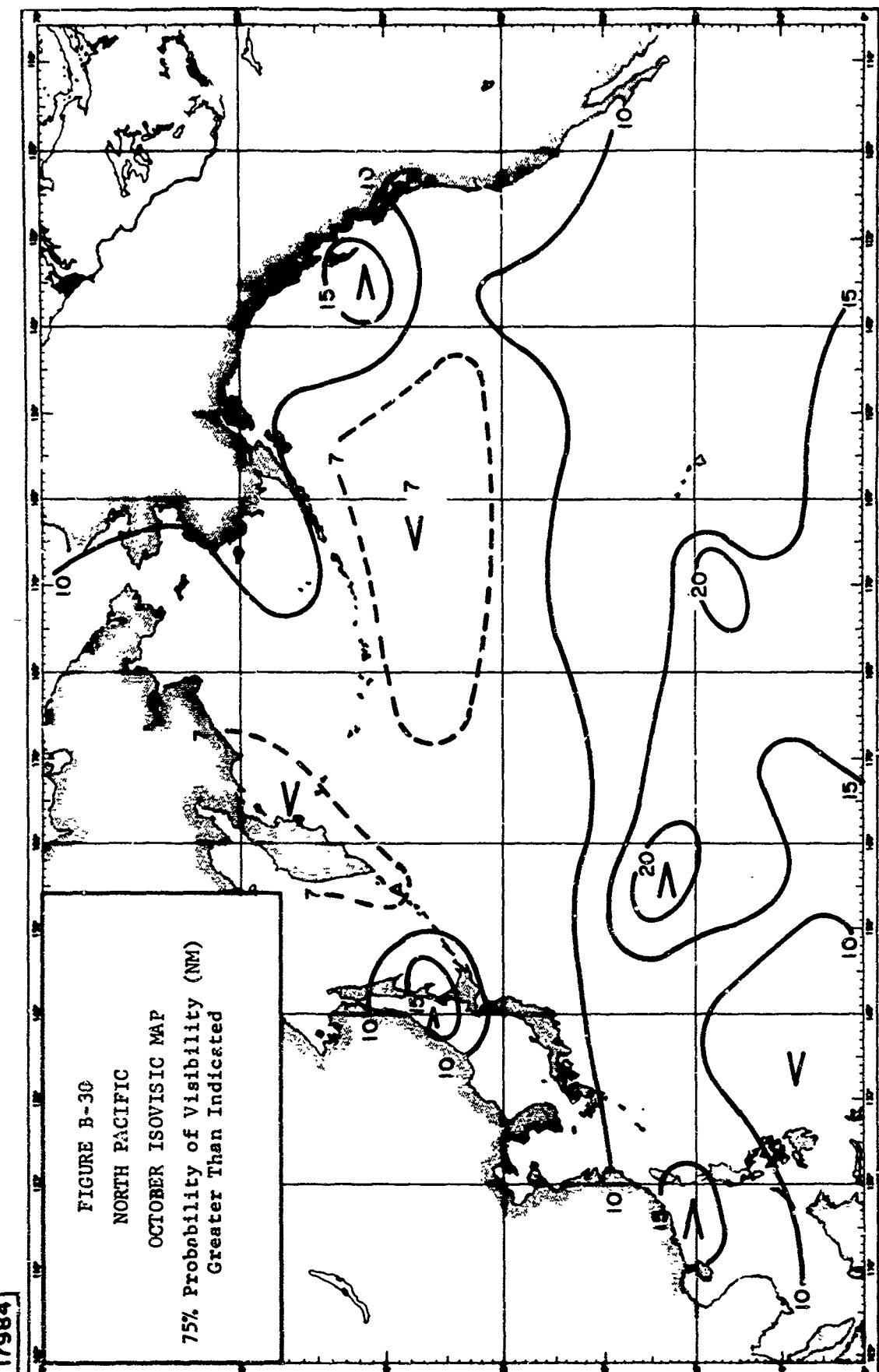


MTR-145



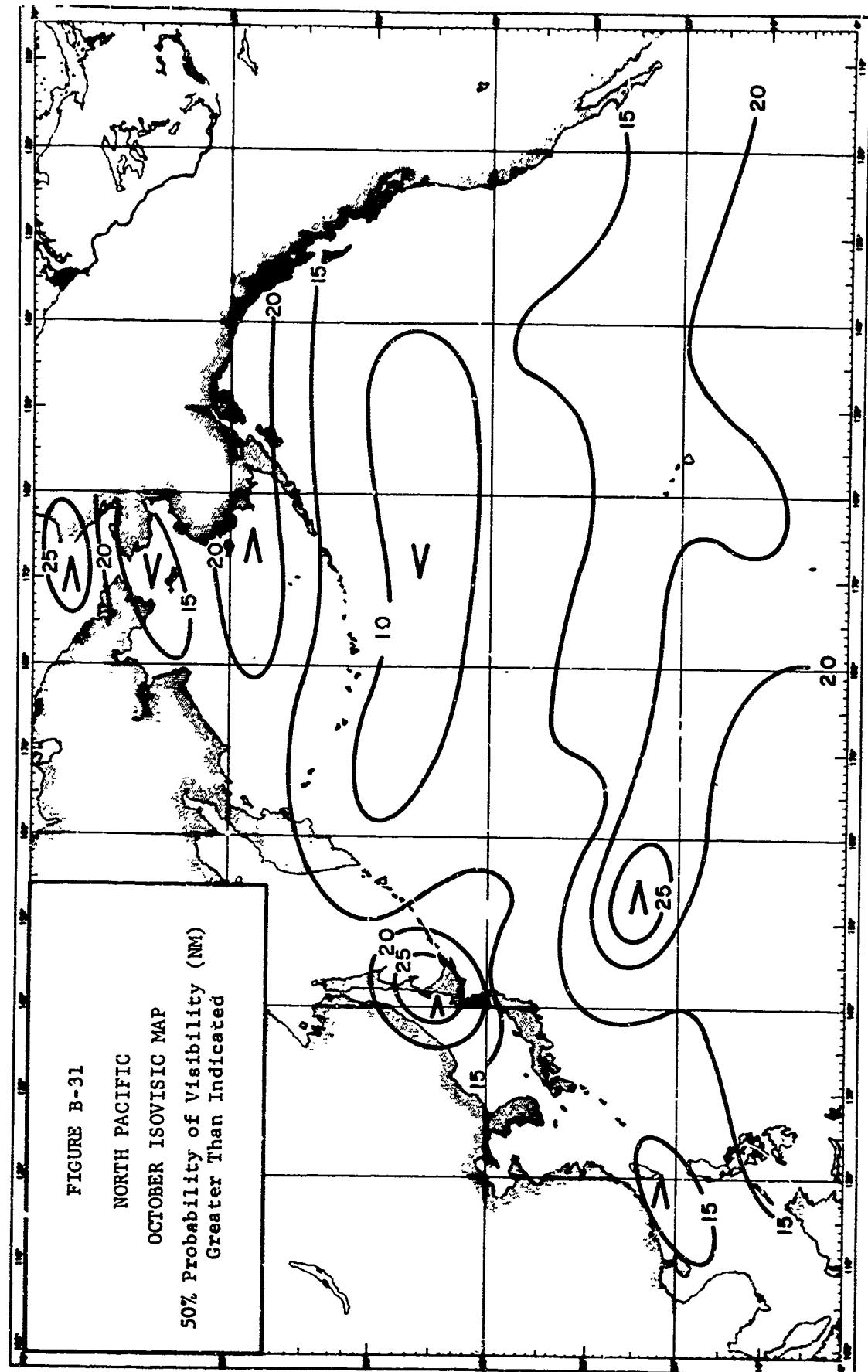
17983

MTR-145



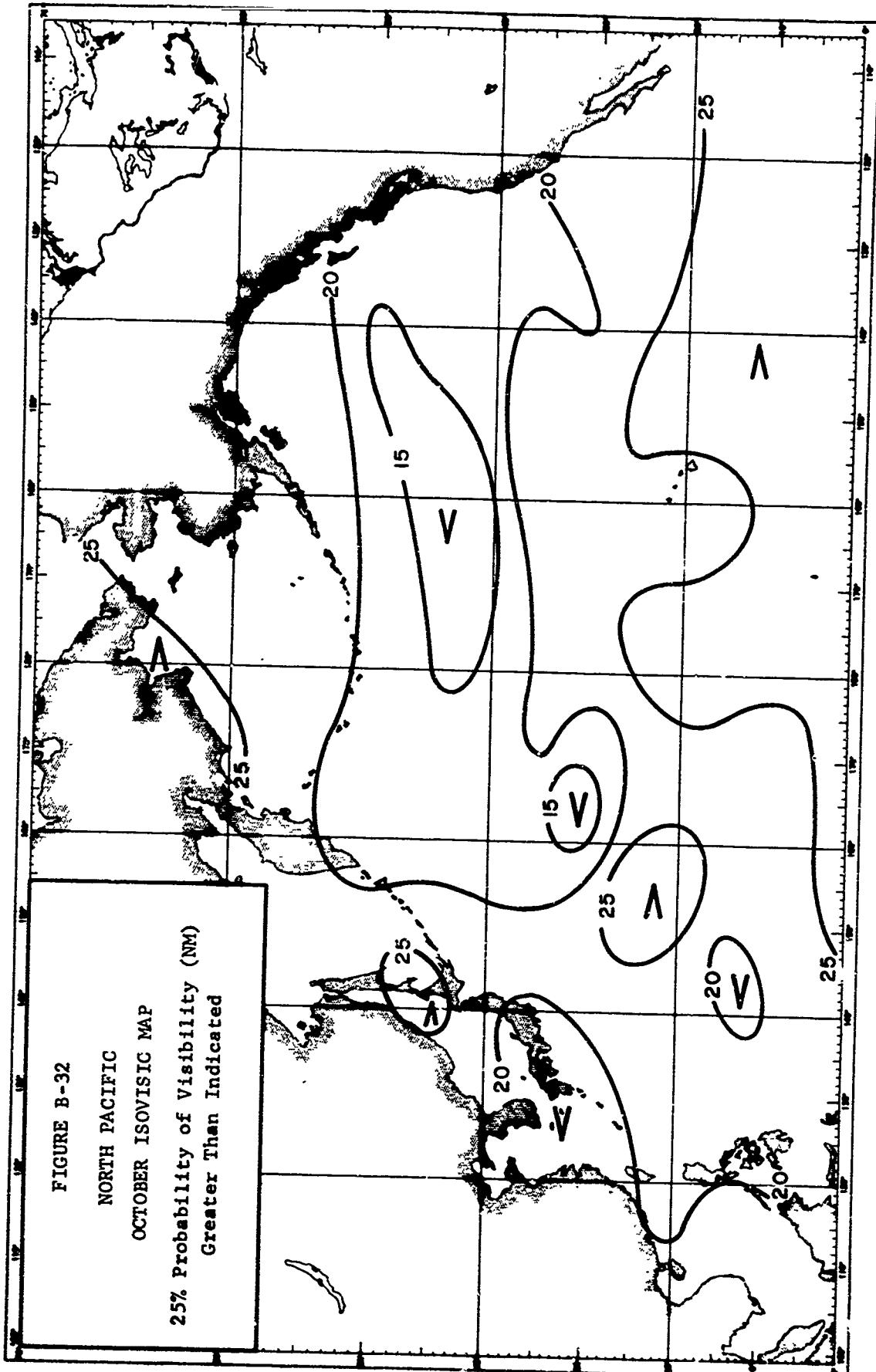
IA-17985

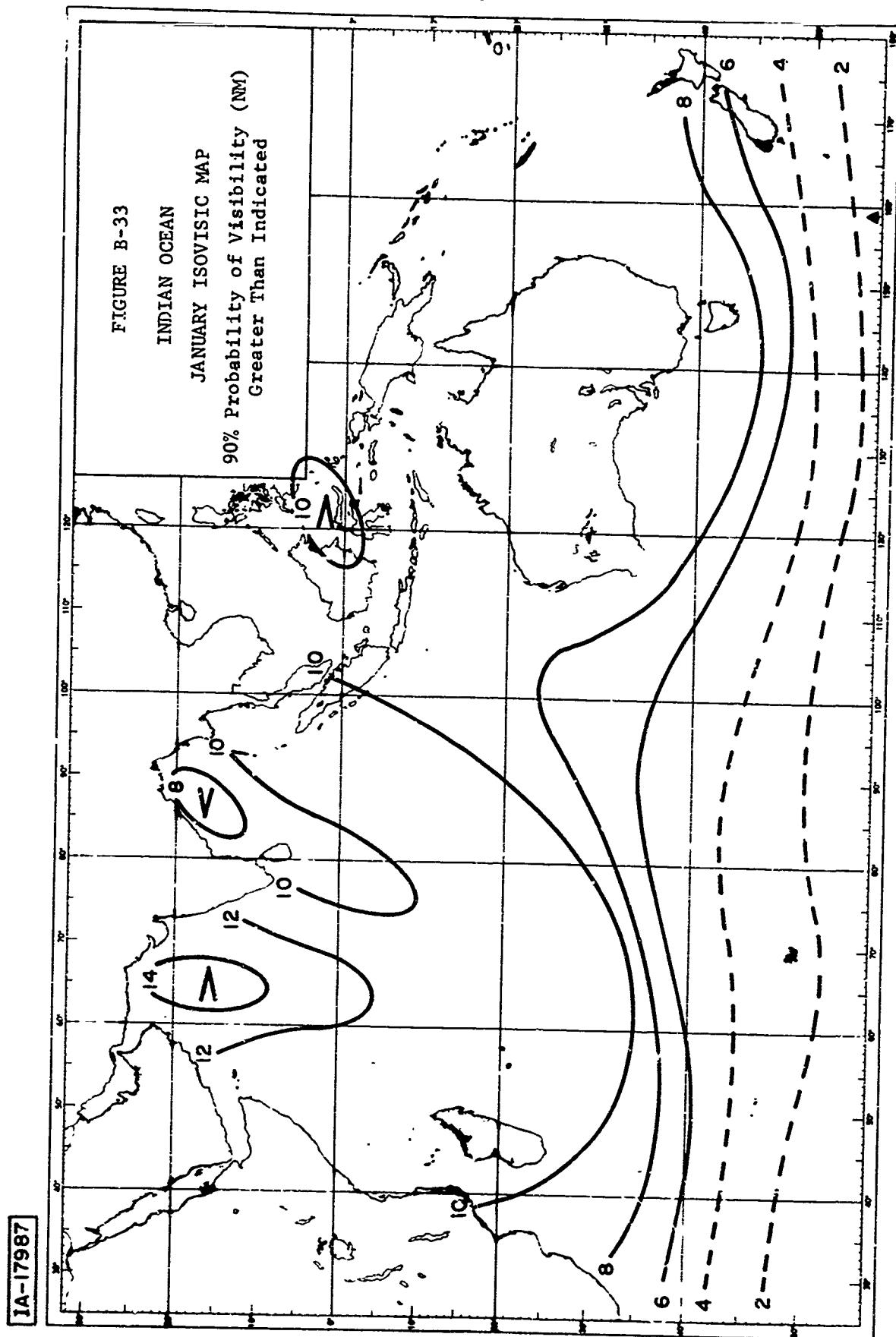
MTR-145



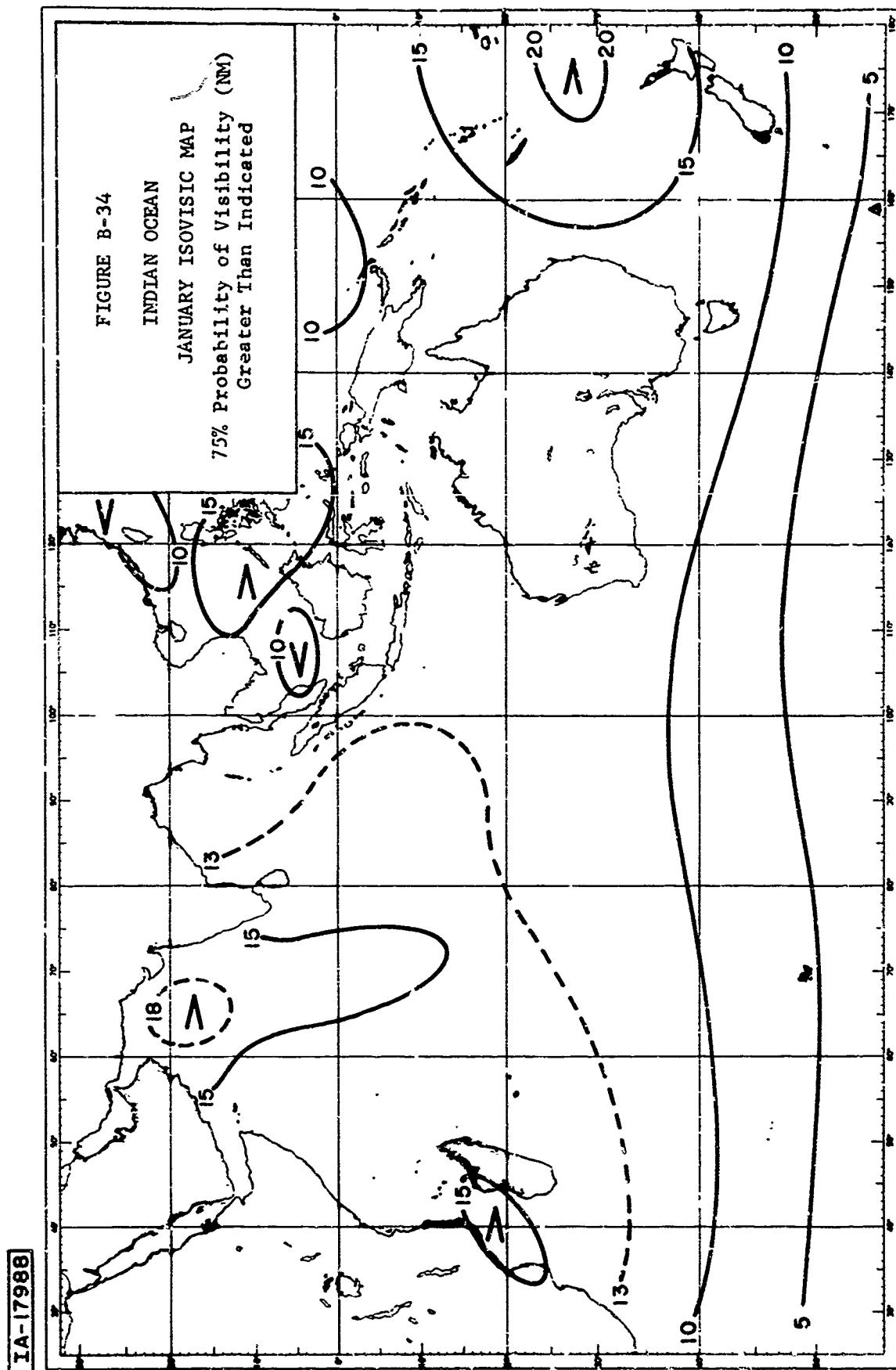
MTR-145

1A-17985

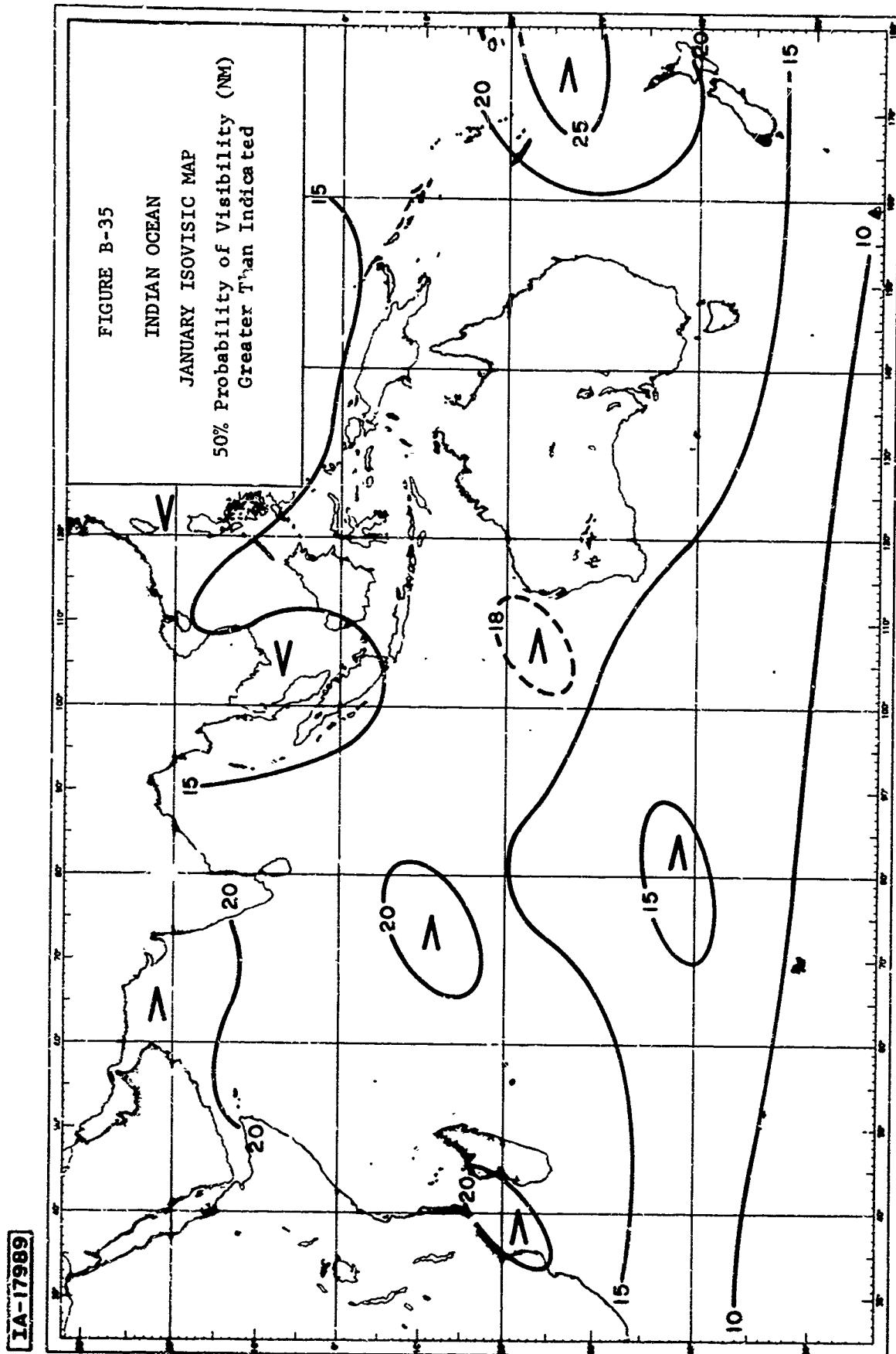




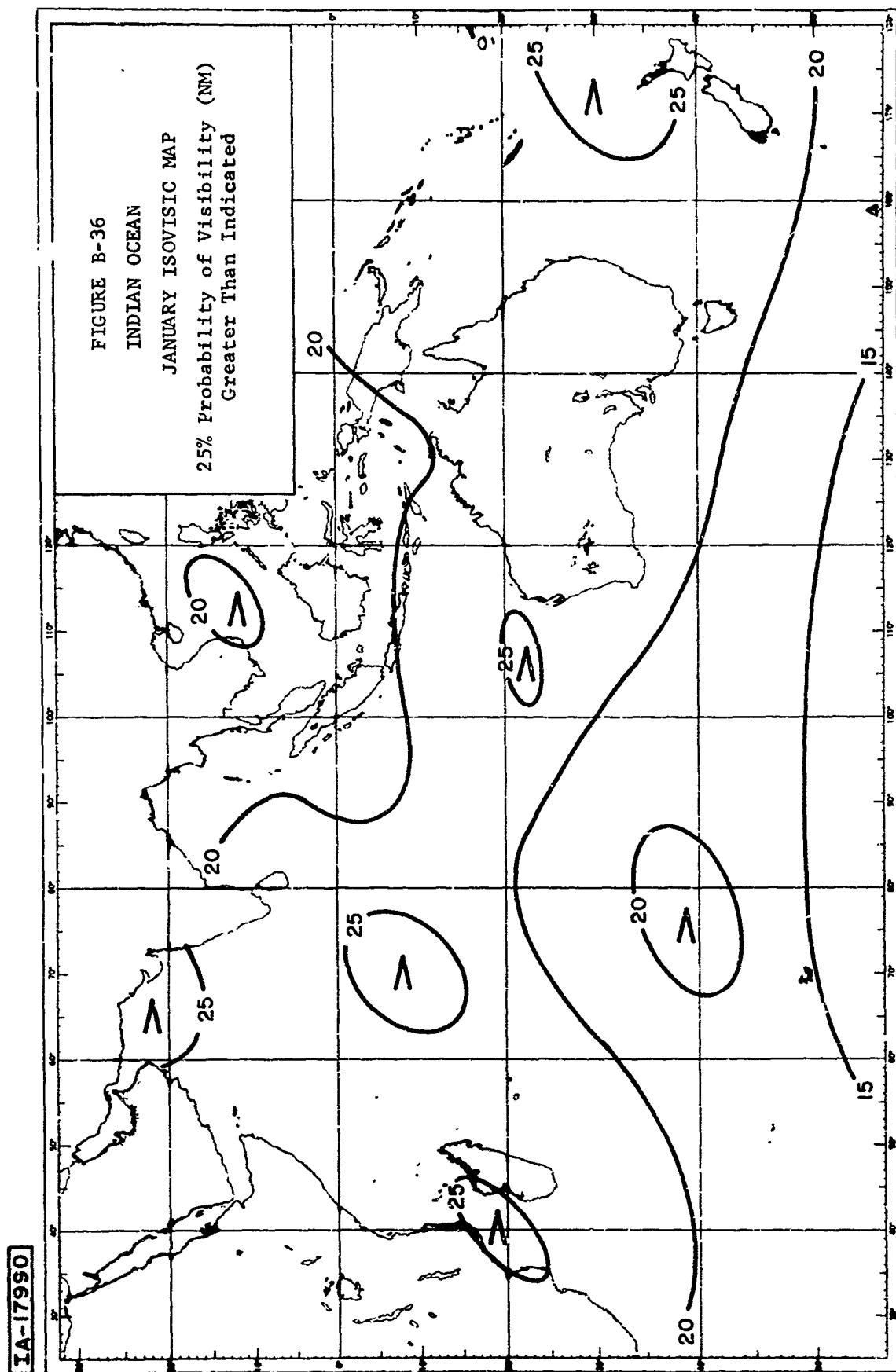
MTR-145



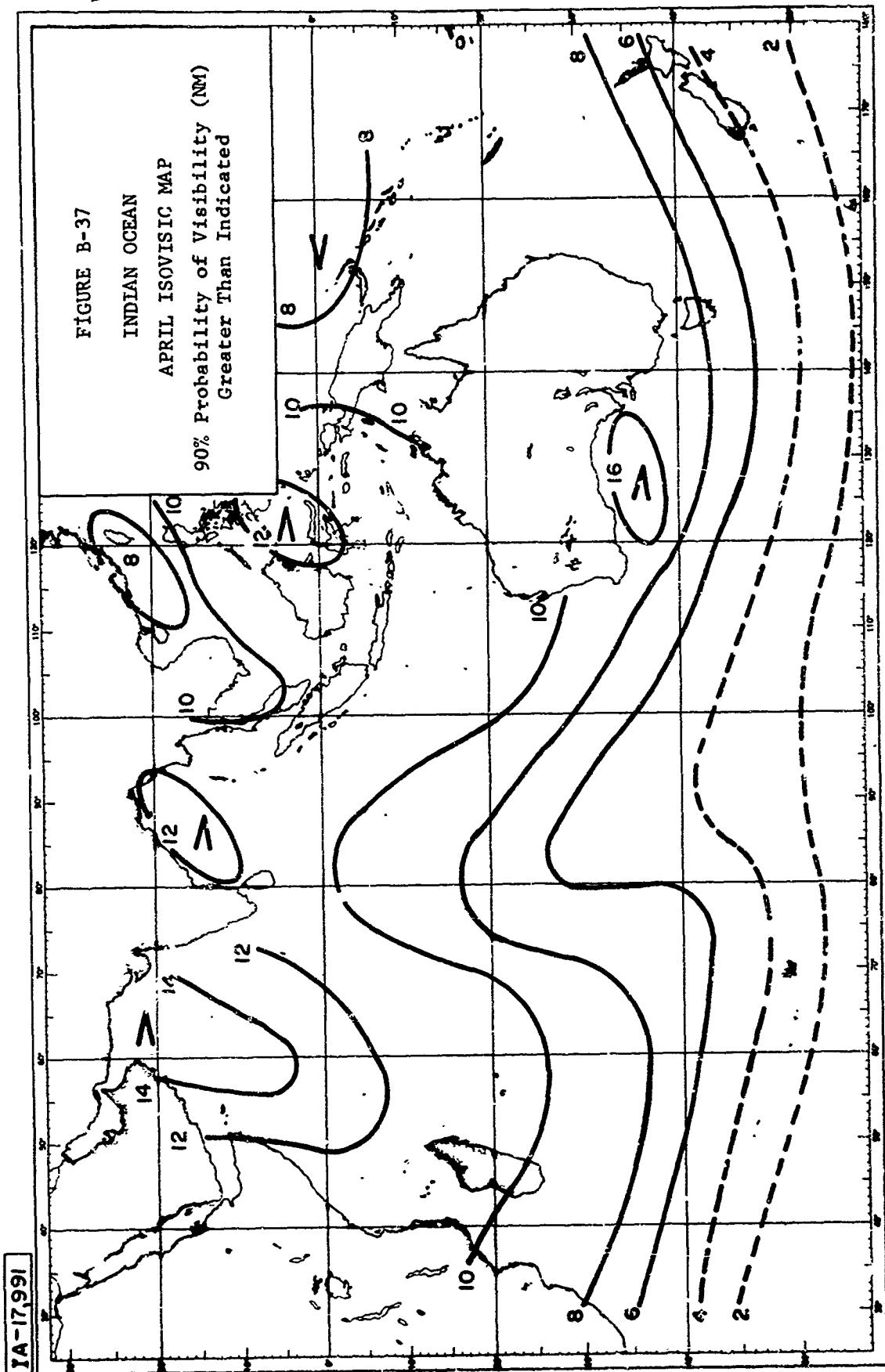
MTR-145



MTR-145

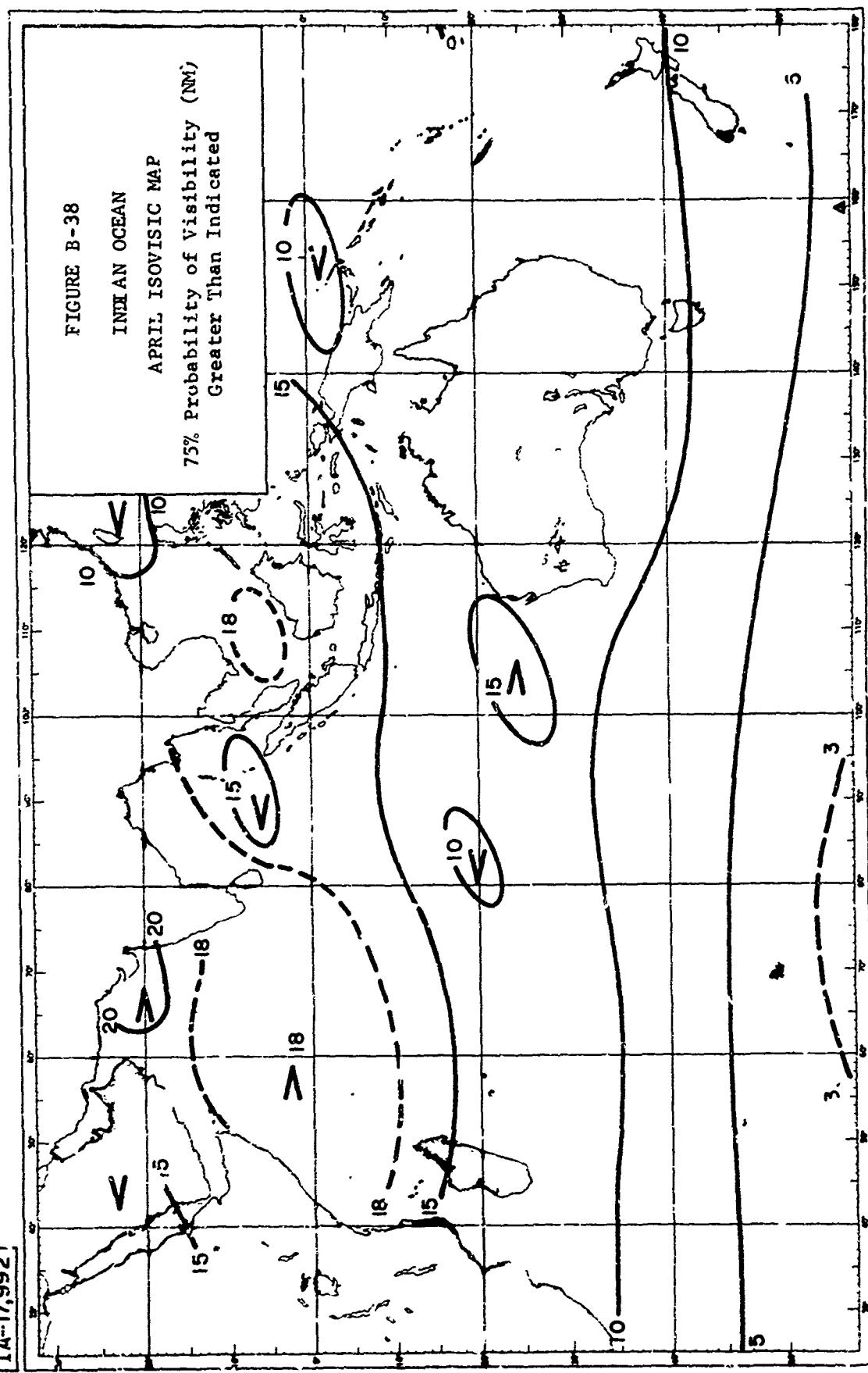


MTR-145



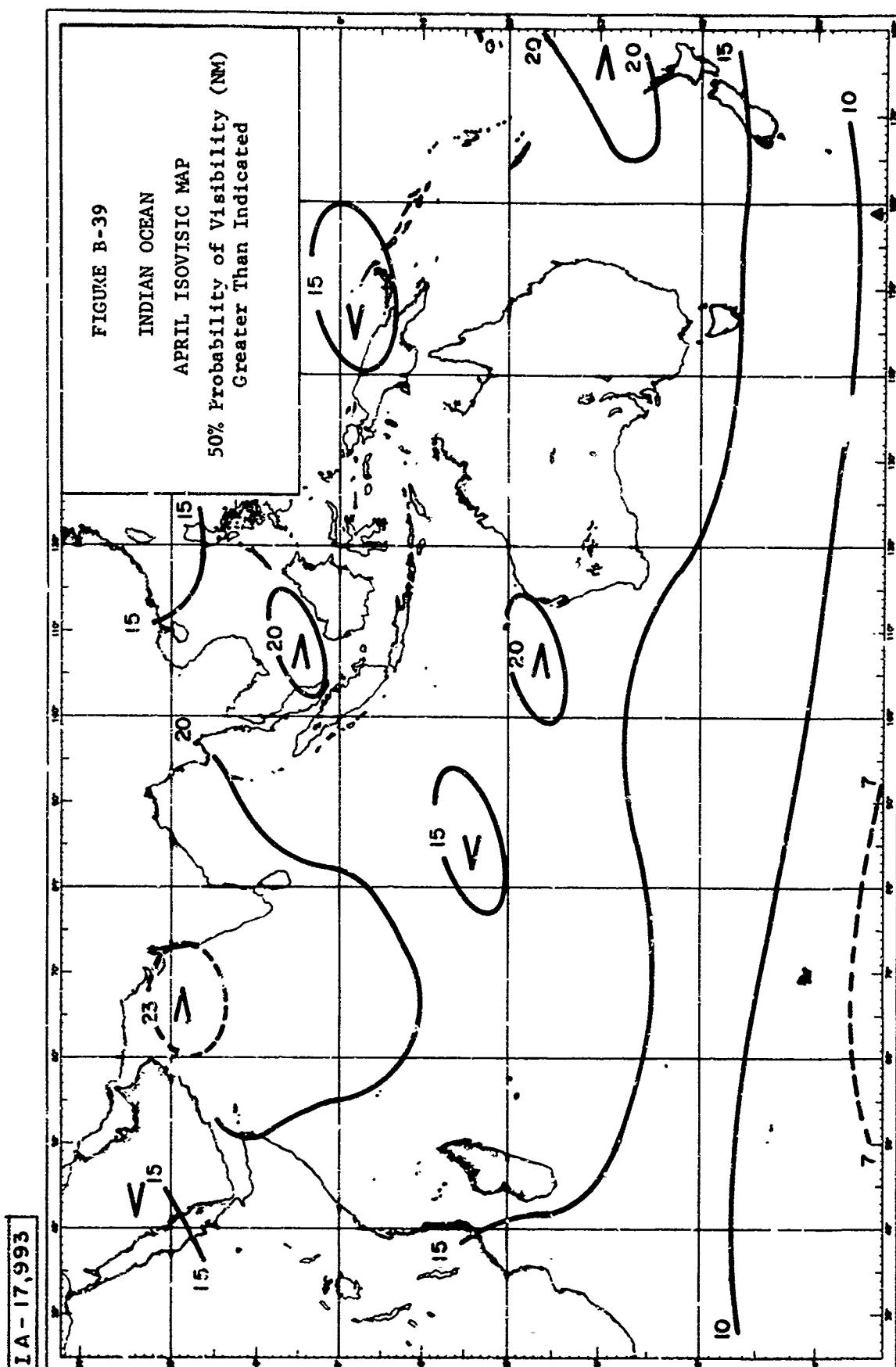
IA-17,992

MTR-145



B-39

MTR-145

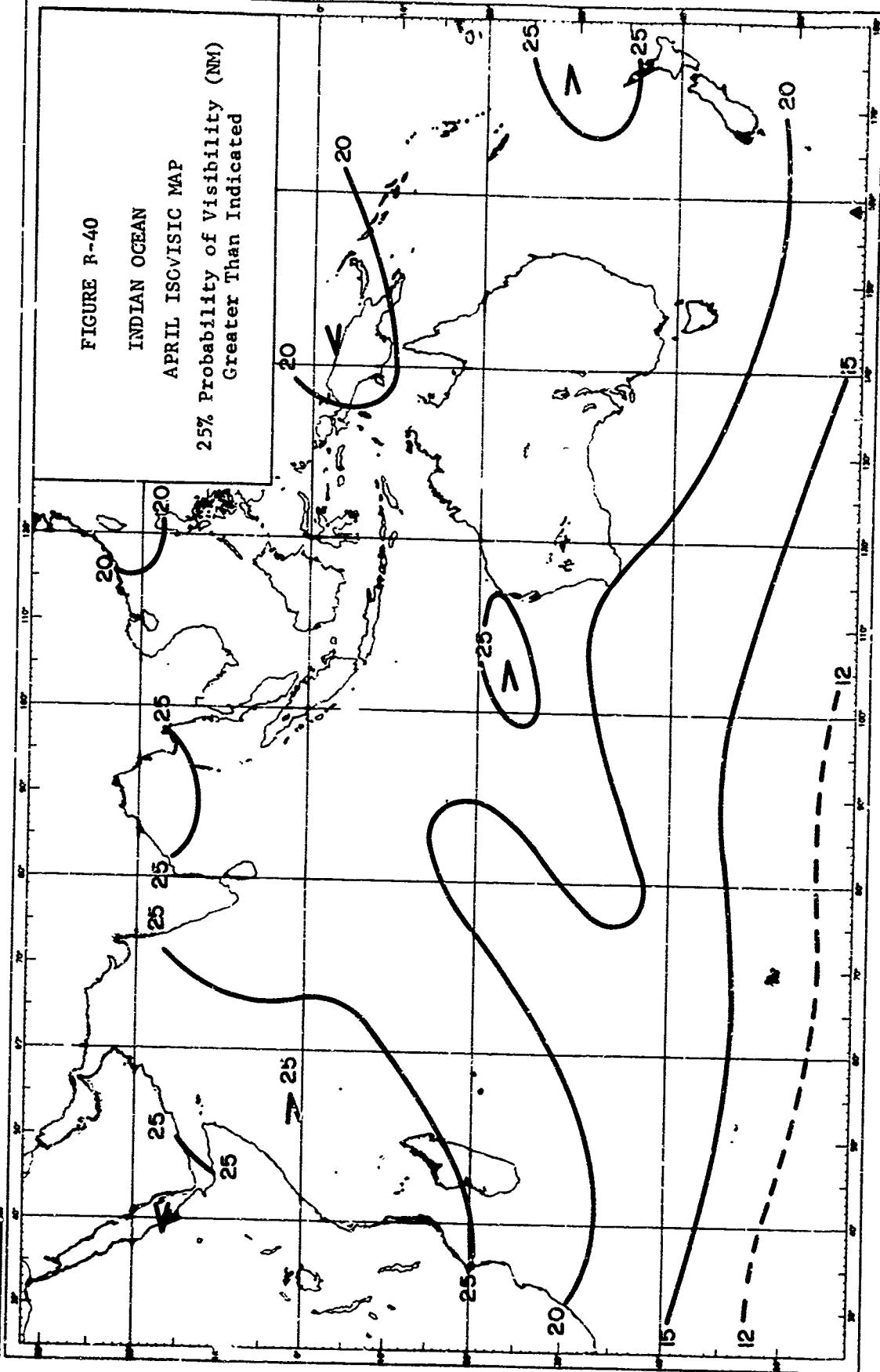


IA-17,994

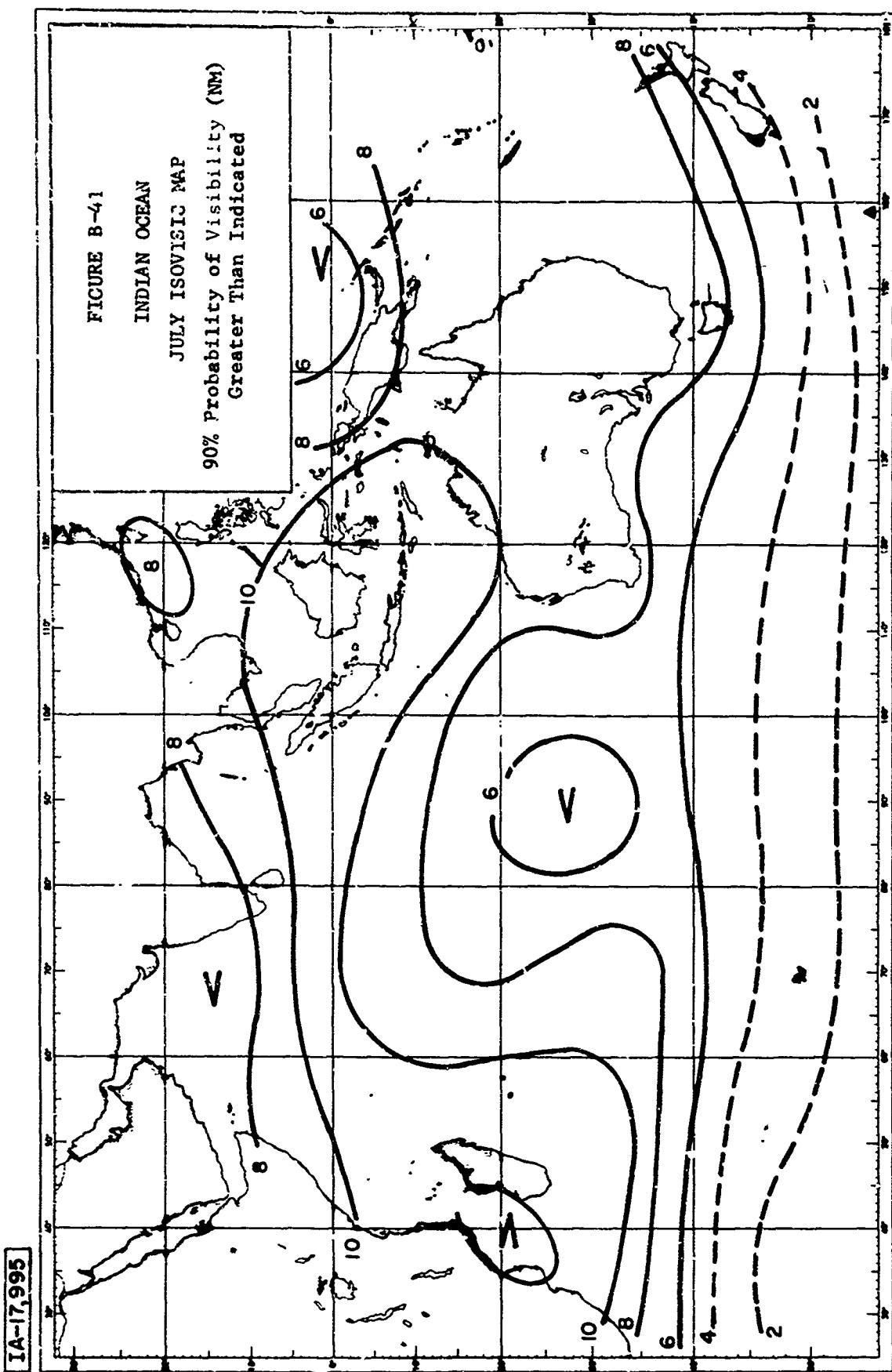
FIGURE R-40

INDIAN OCEAN
APRIL ISCVISIC MAP
25% Probability of Visibility (NM)
Greater Than Indicated

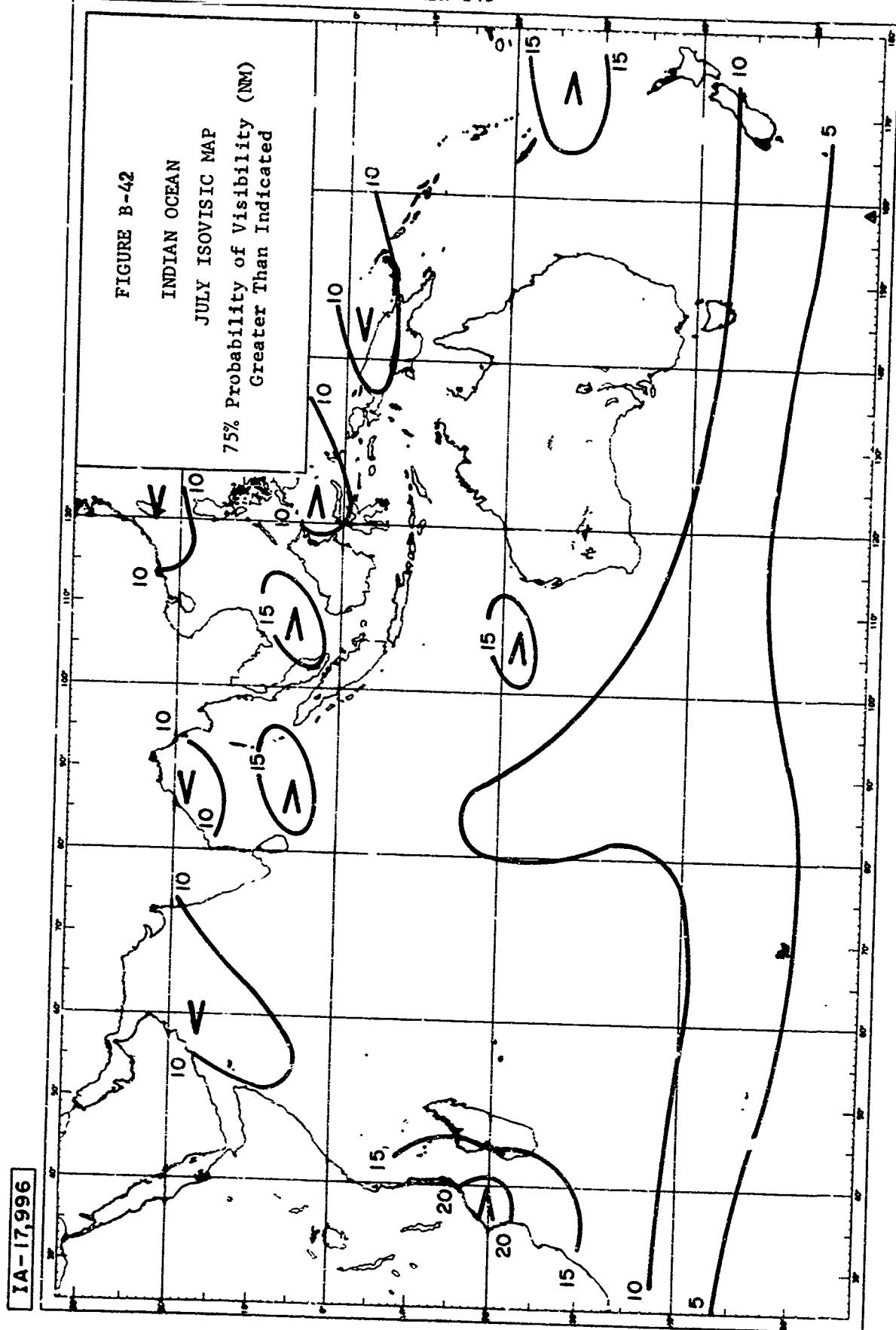
MIR-145



MITR-145

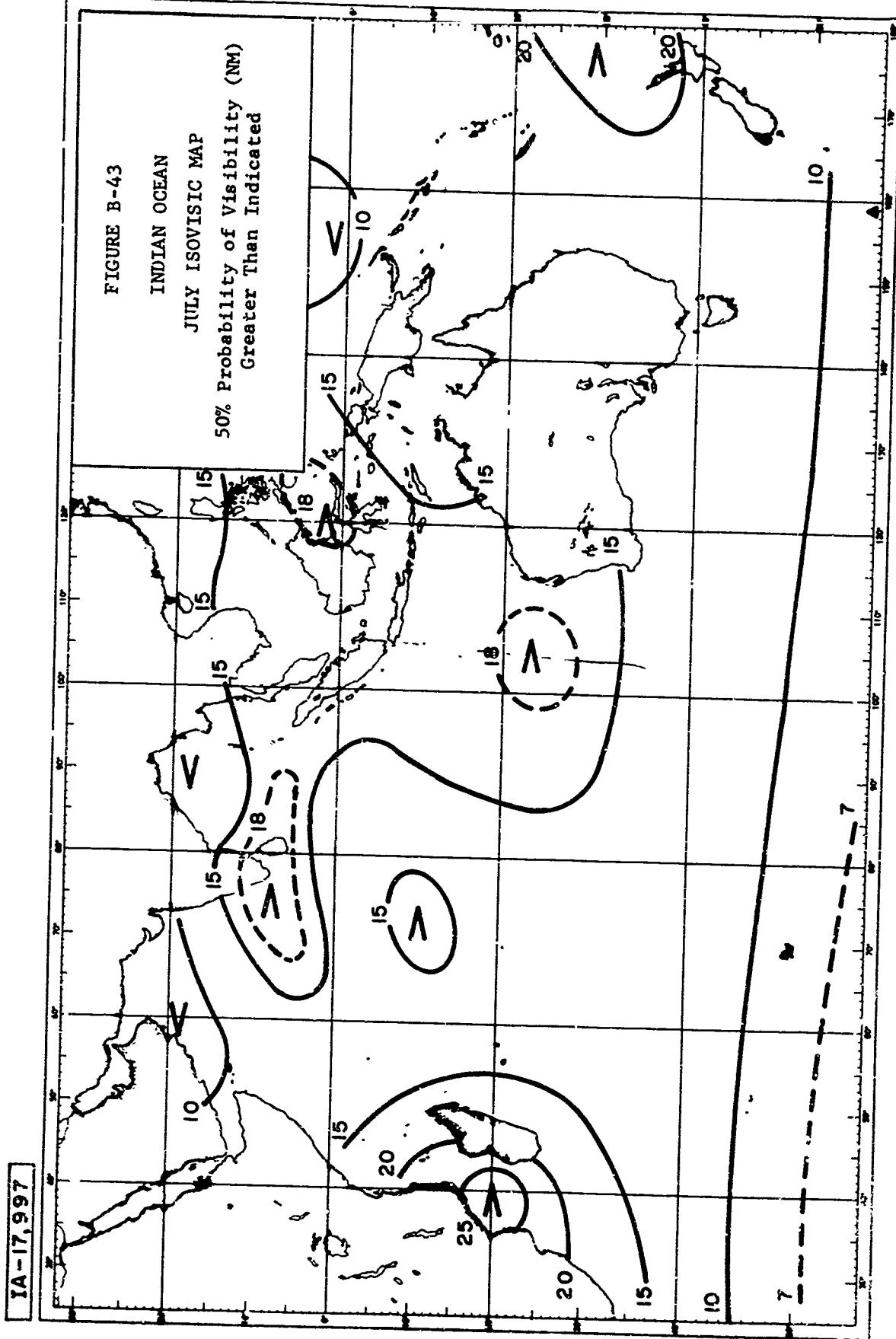


MTR-145



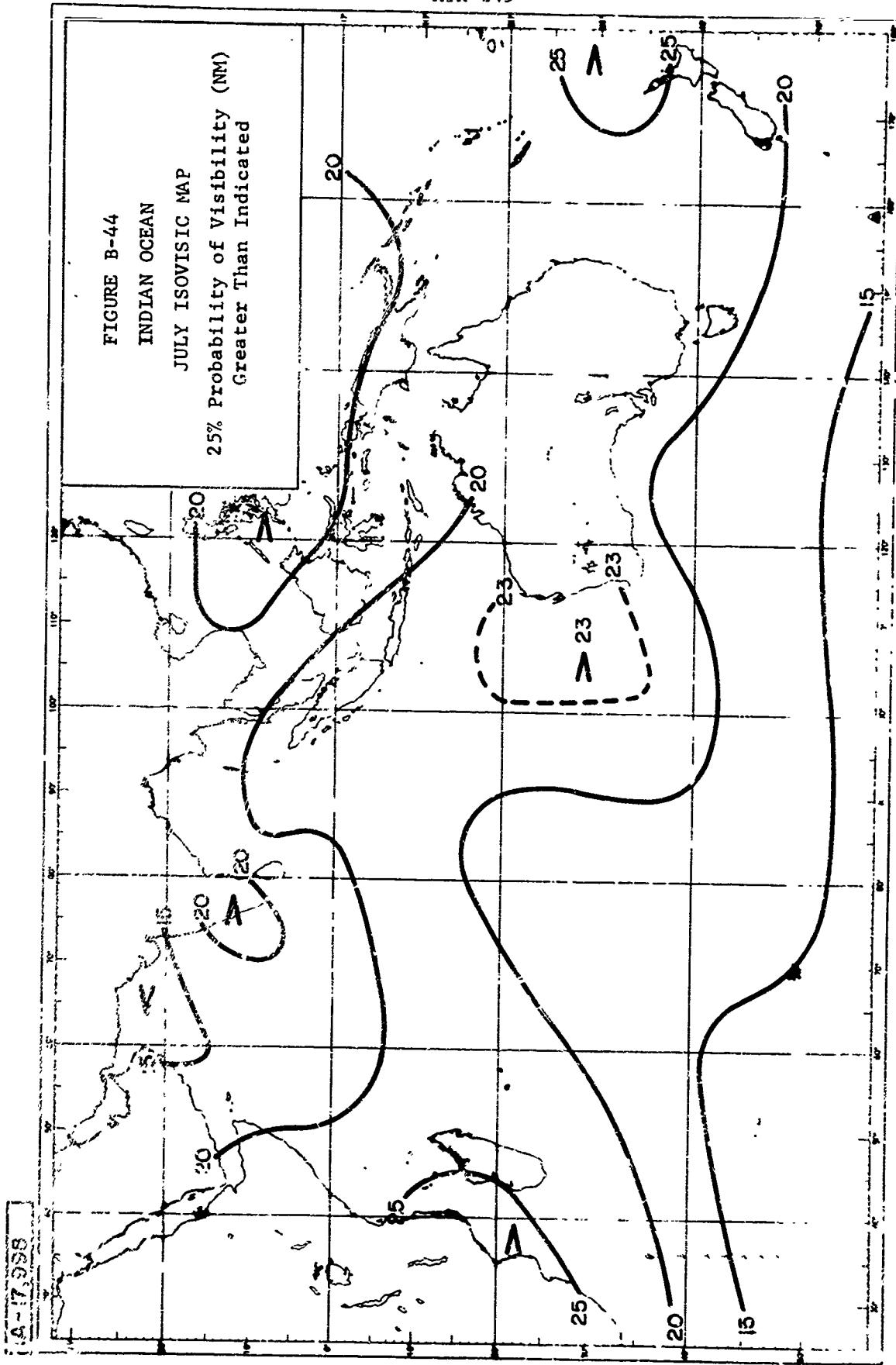
MTR-145

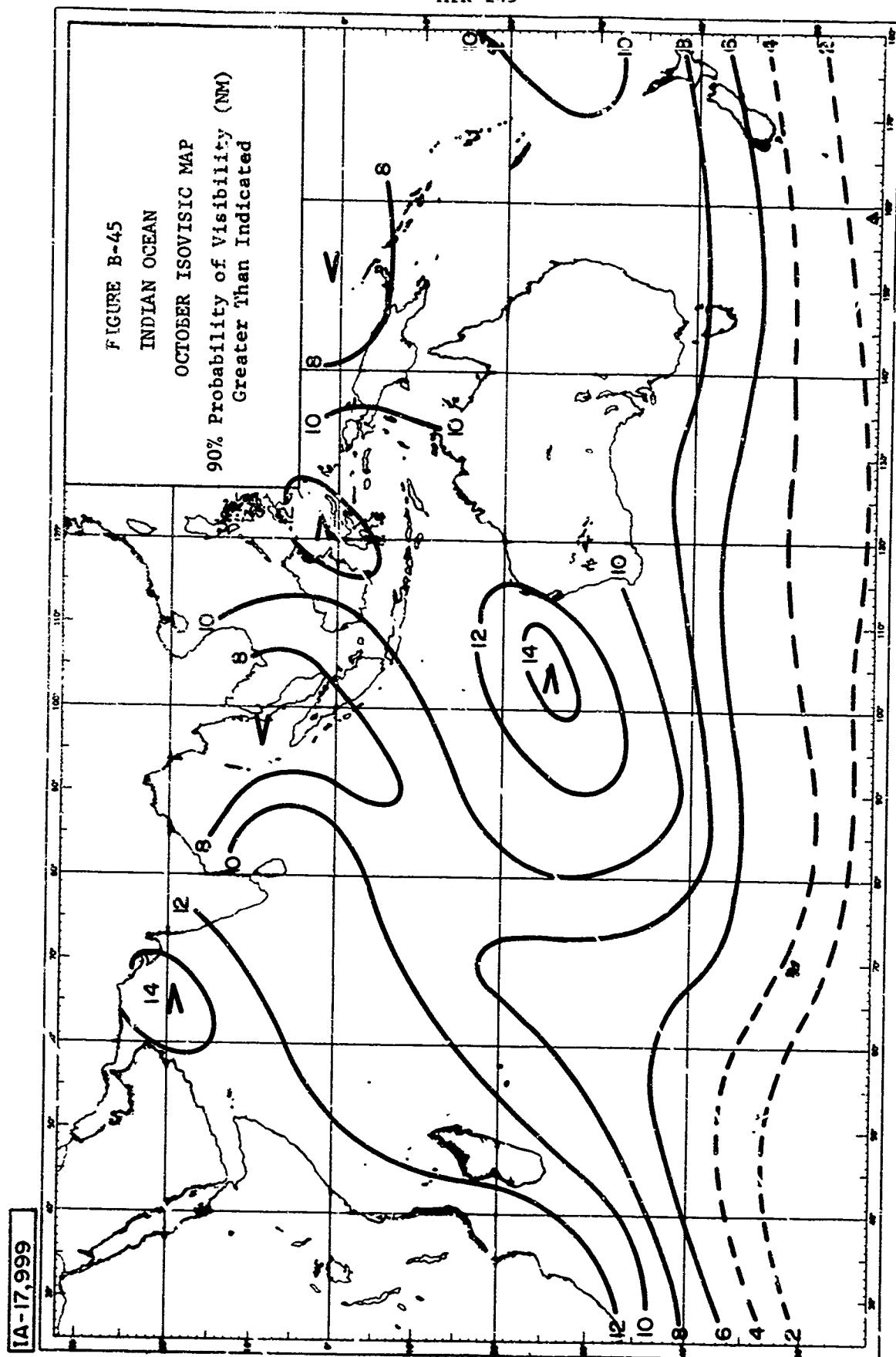
FIGURE B-43
INDIAN OCEAN
JULY ISOVISIC MAP
50% Probability of Visibility (NM)
Greater Than Indicated



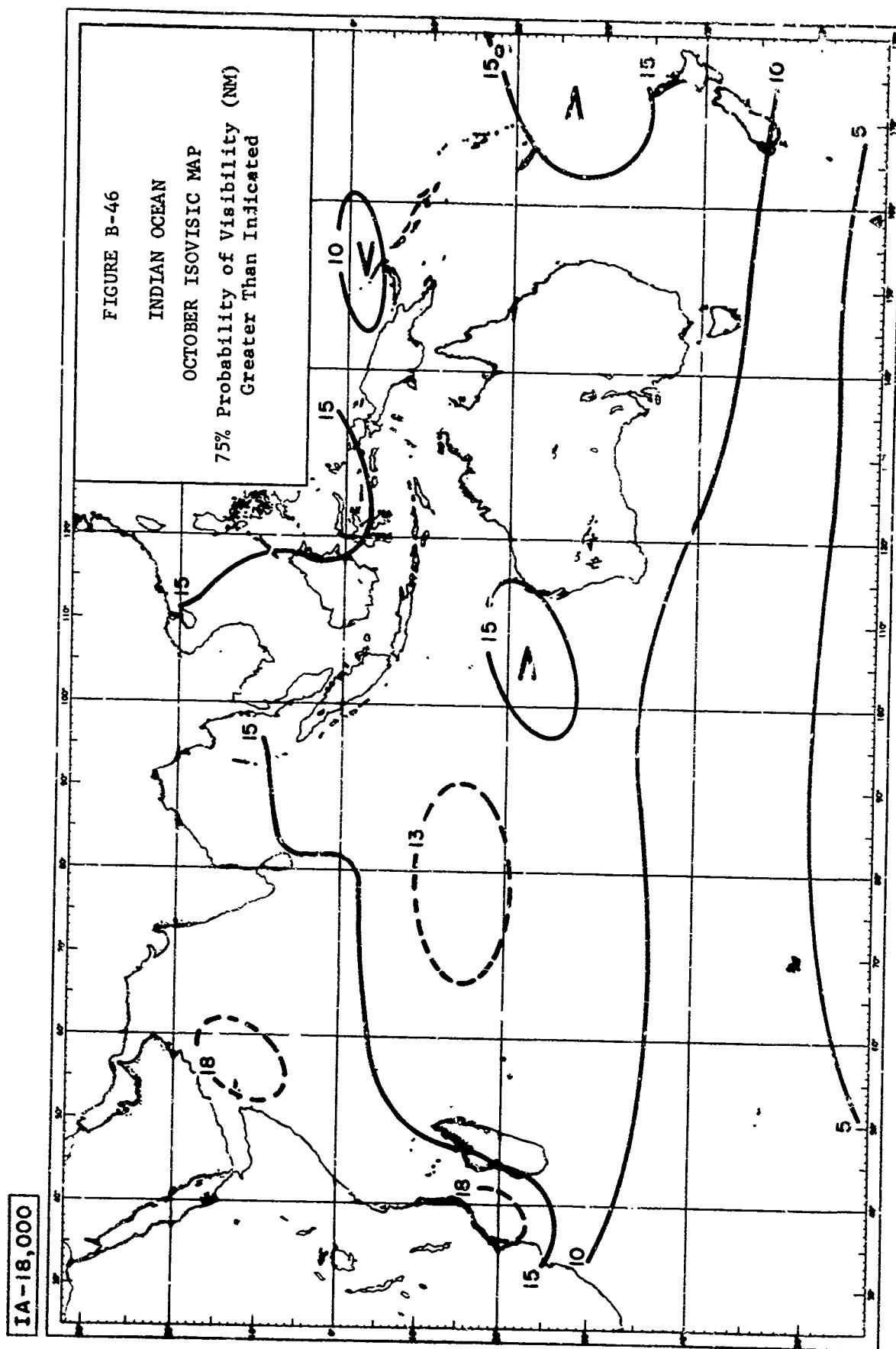
TA-17,997

FIGURE B-44
INDIAN OCEAN
JULY ISOVISIC MAP
25% Probability of Visibility (NM)
Greater Than Indicated

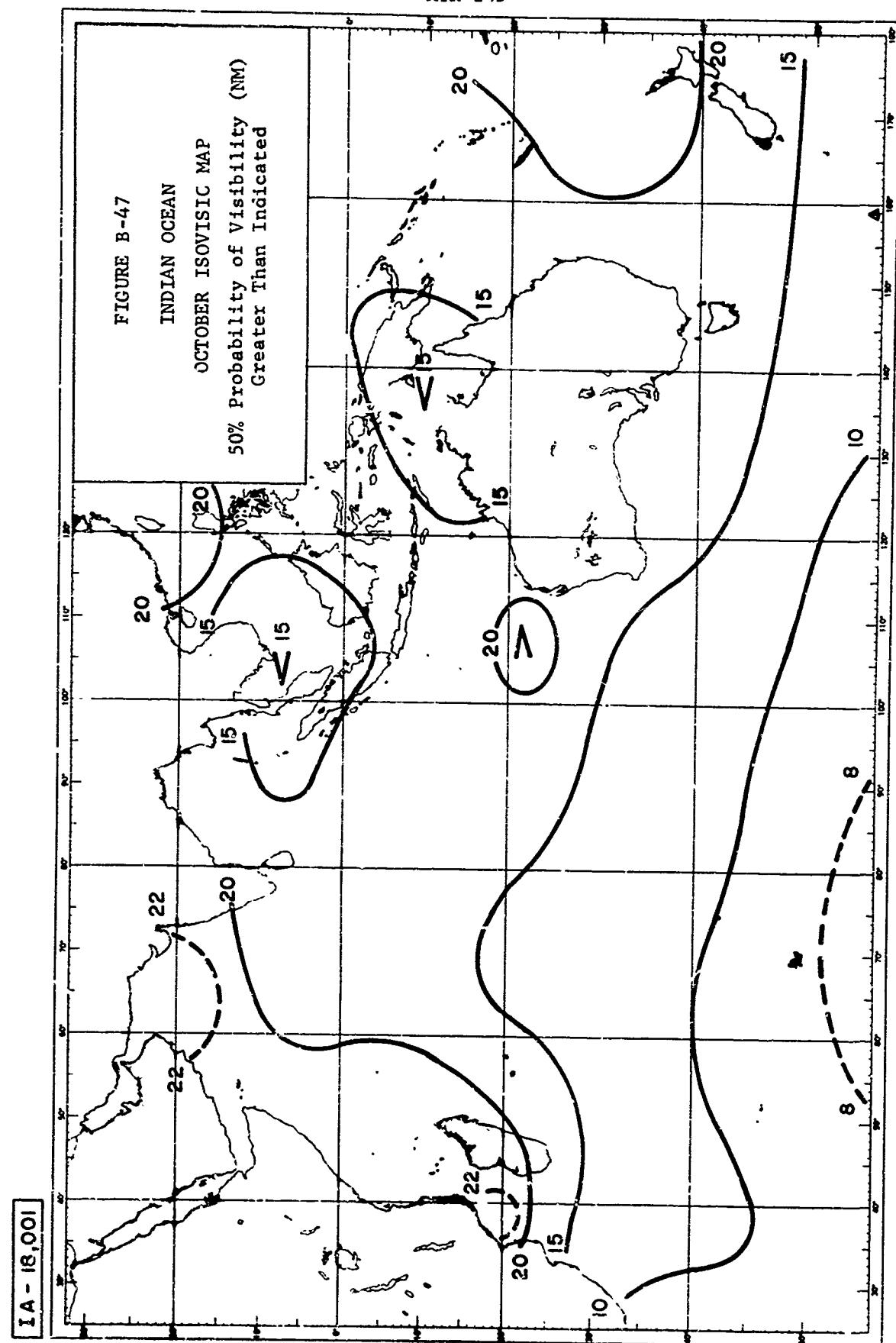




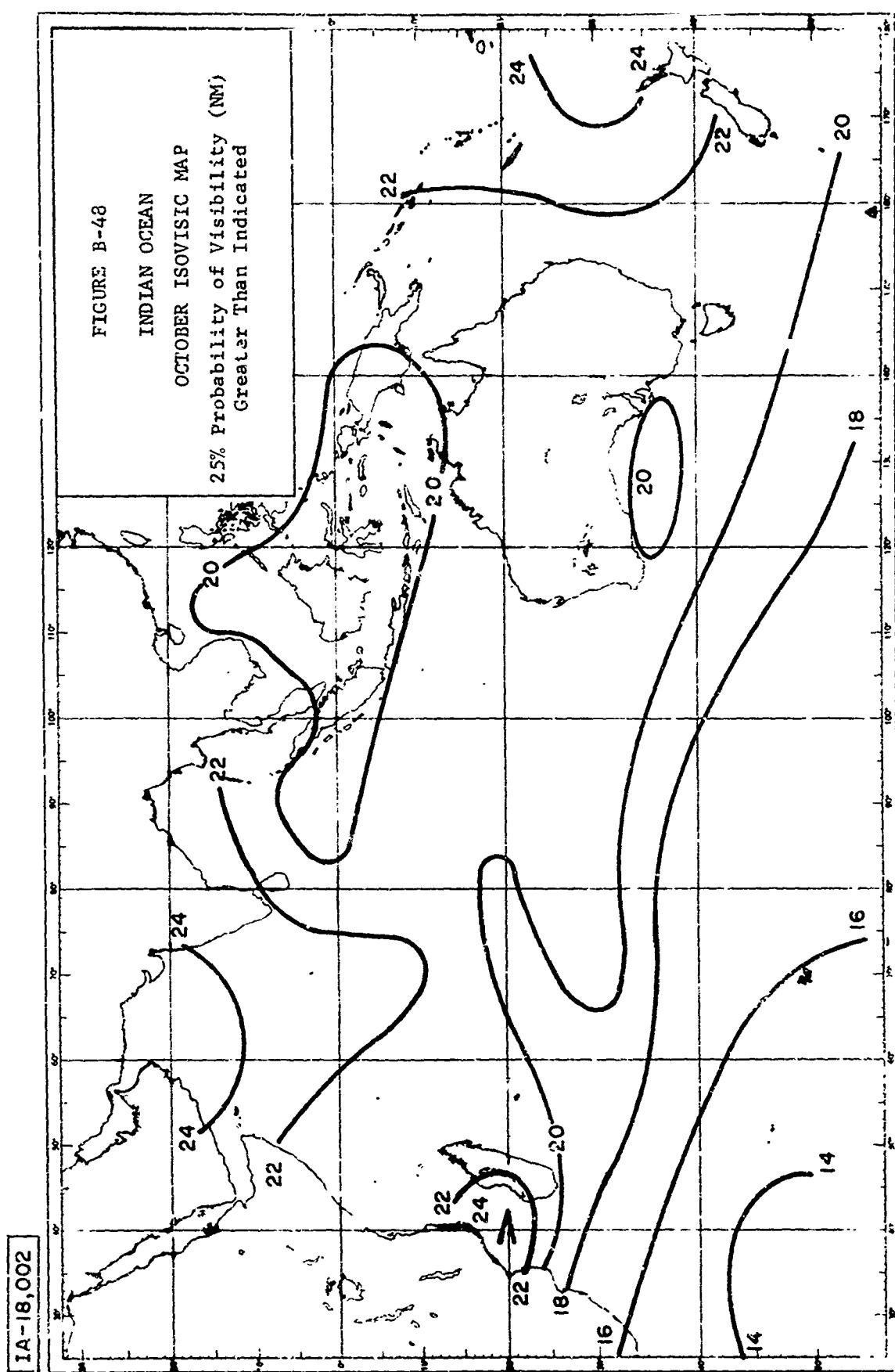
MTR-145



MTR-145



MTR-145

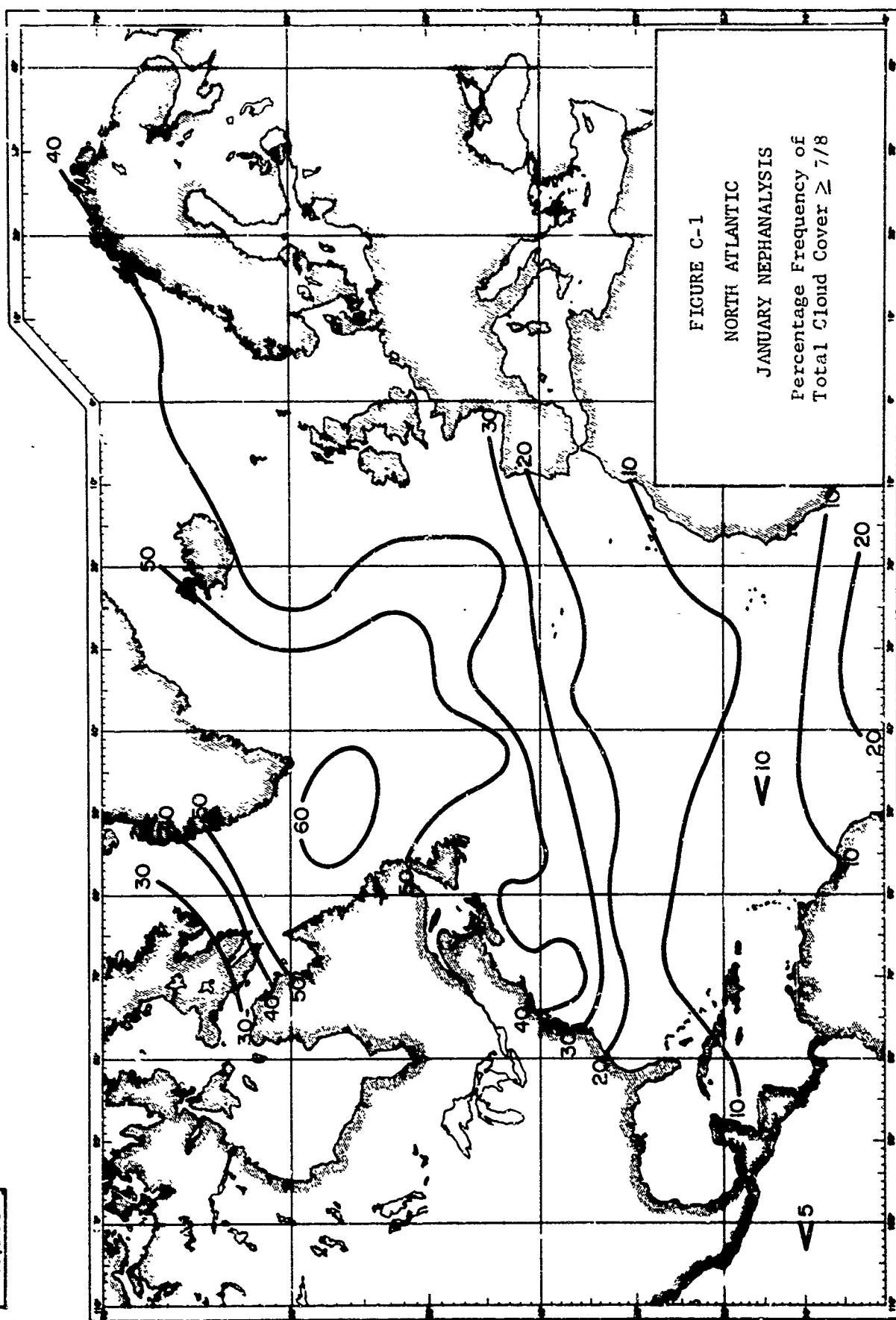


B-49

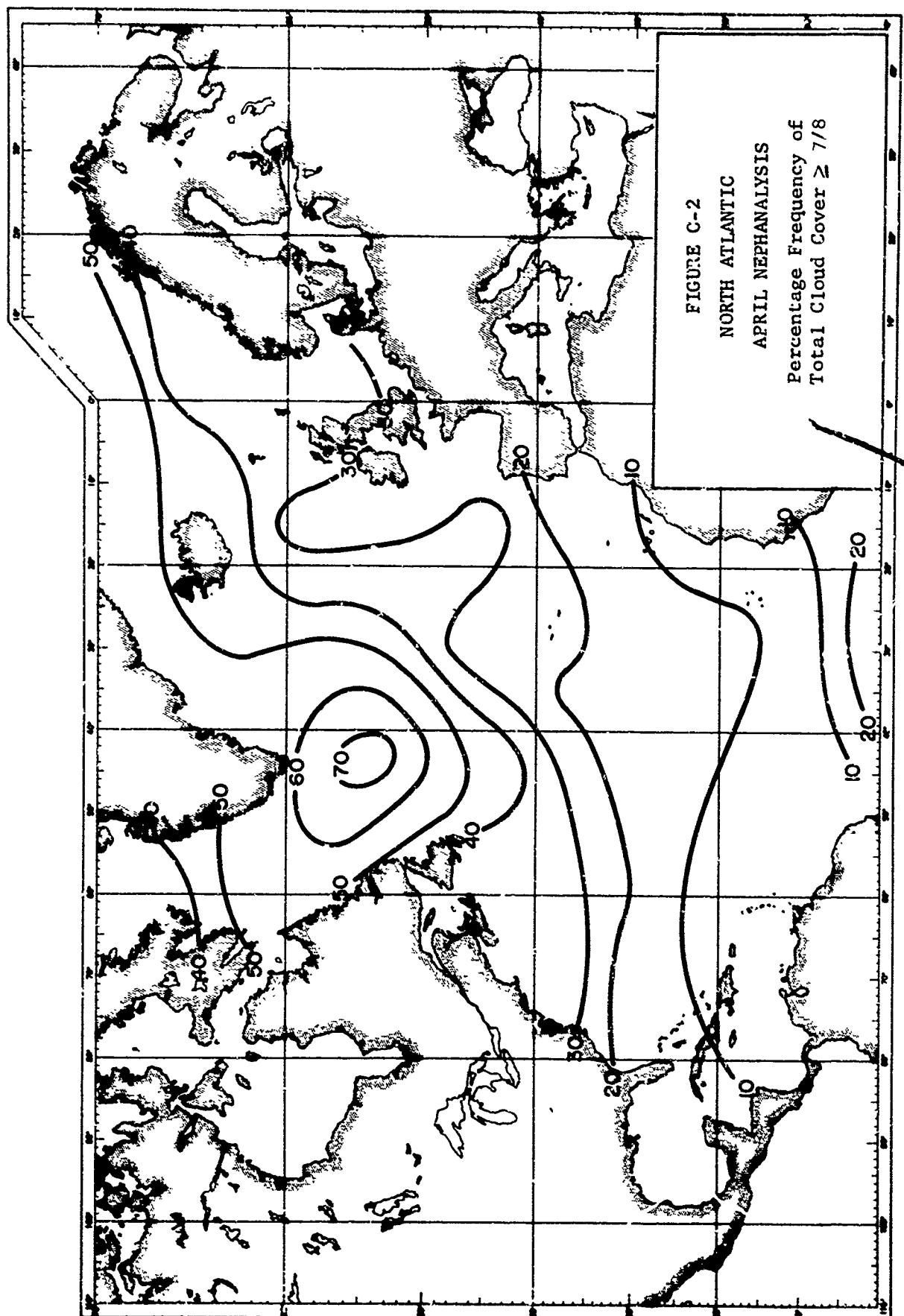
APPENDIX C

NEPHANALYSIS - PERCENTAGE FREQUENCY OF TOT. CLOUD COVER $\geq 7/8$

IA-18.063

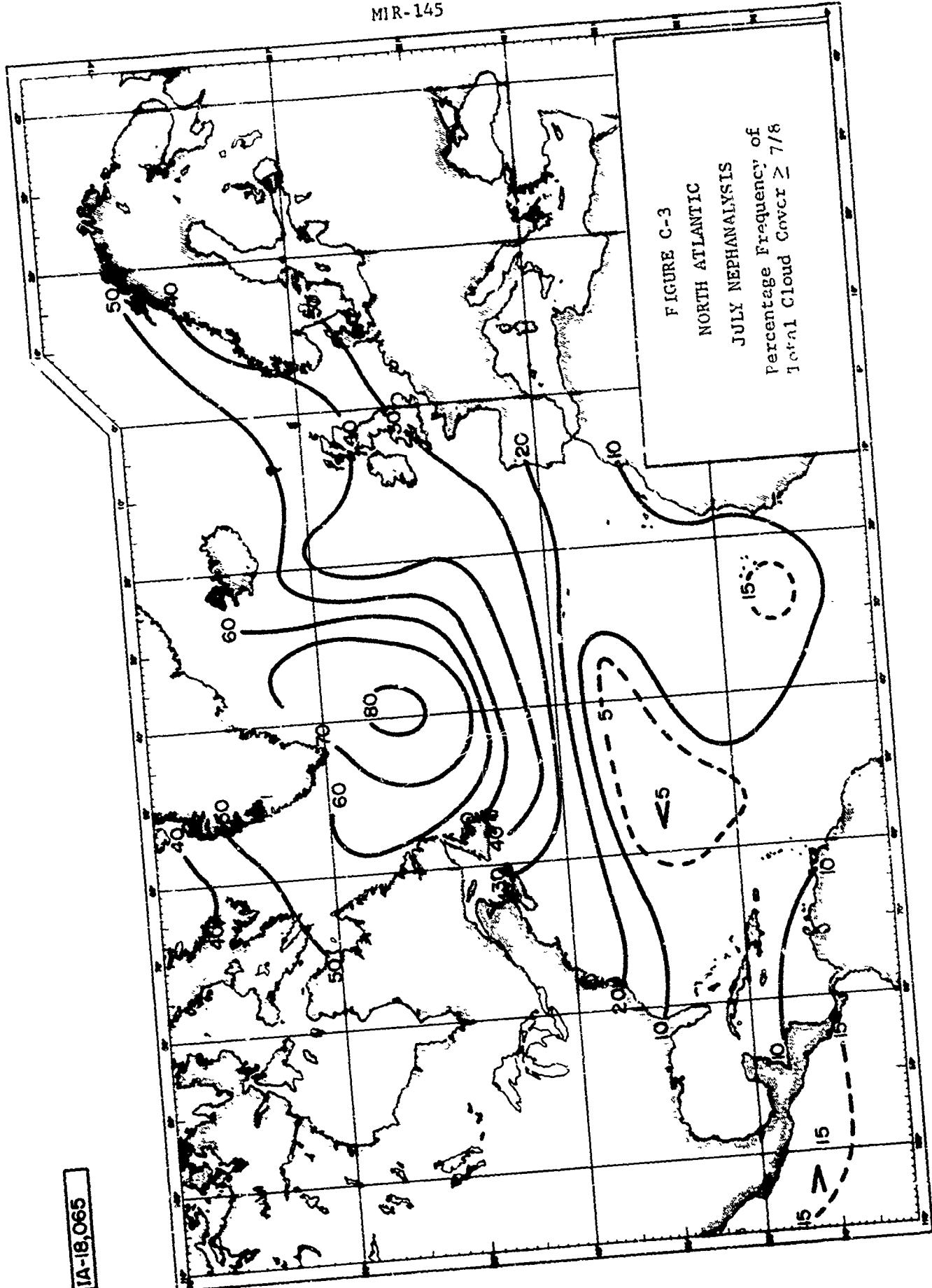


MIR-145

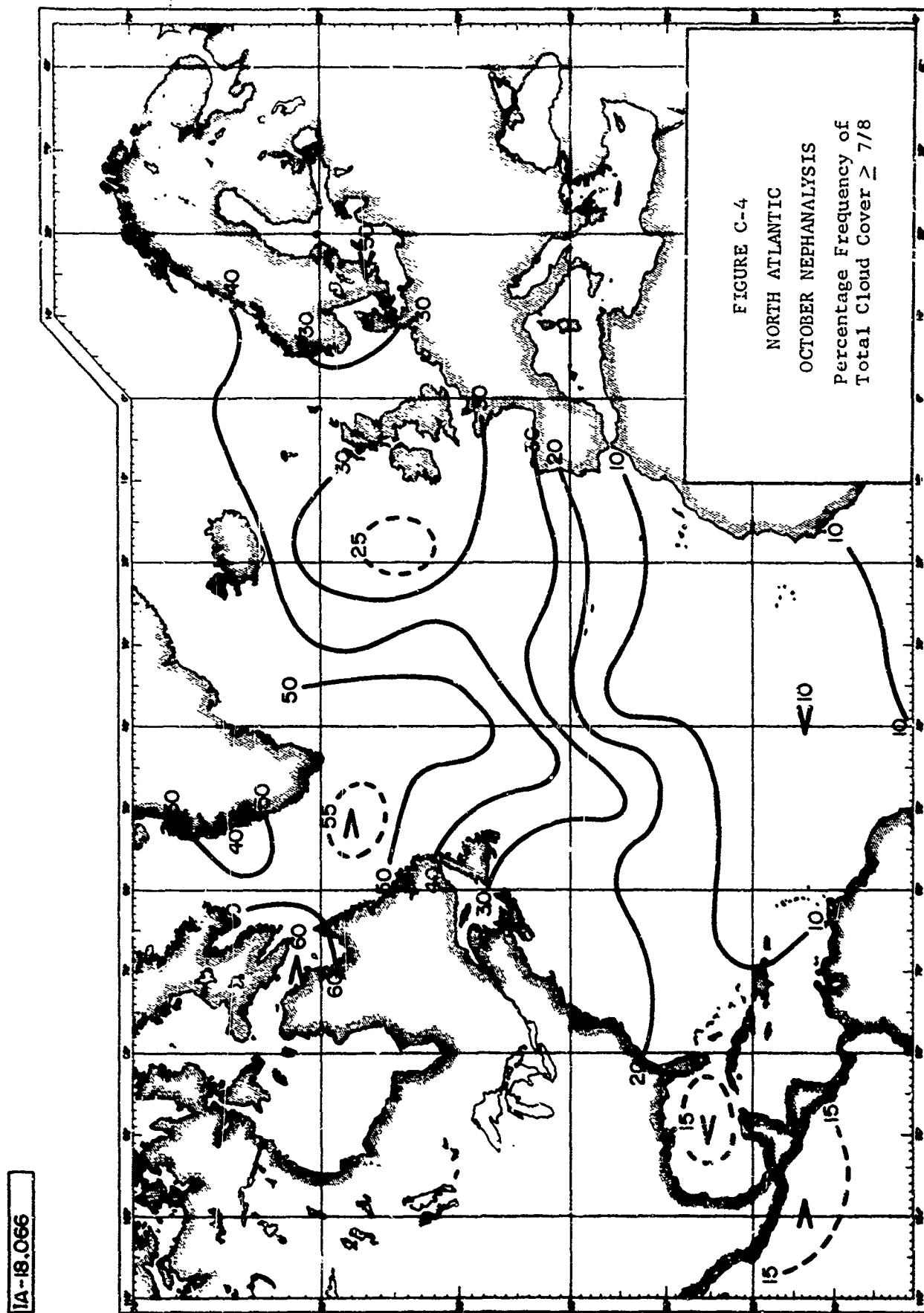


LA-18,064

MIR-145

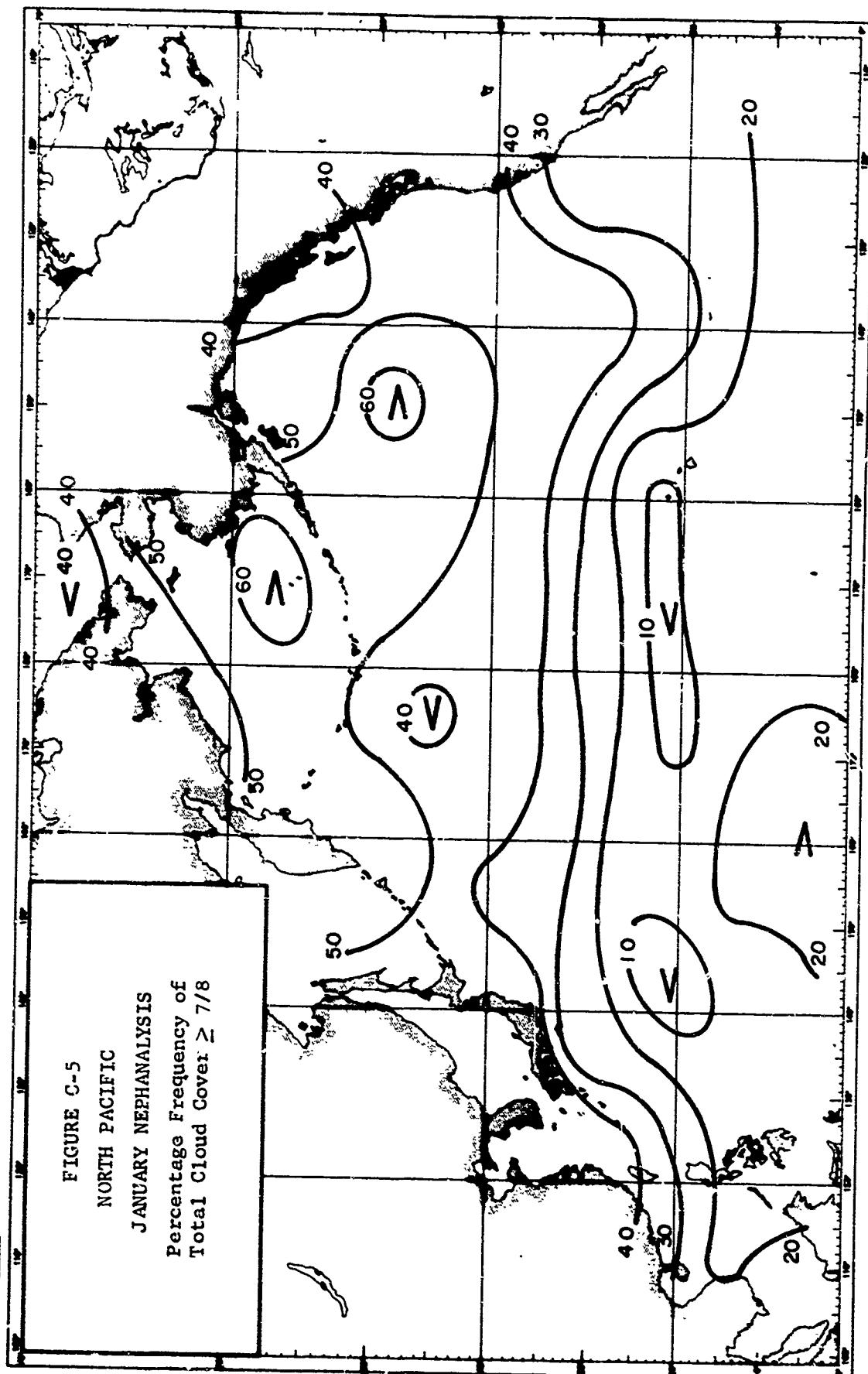


C-4

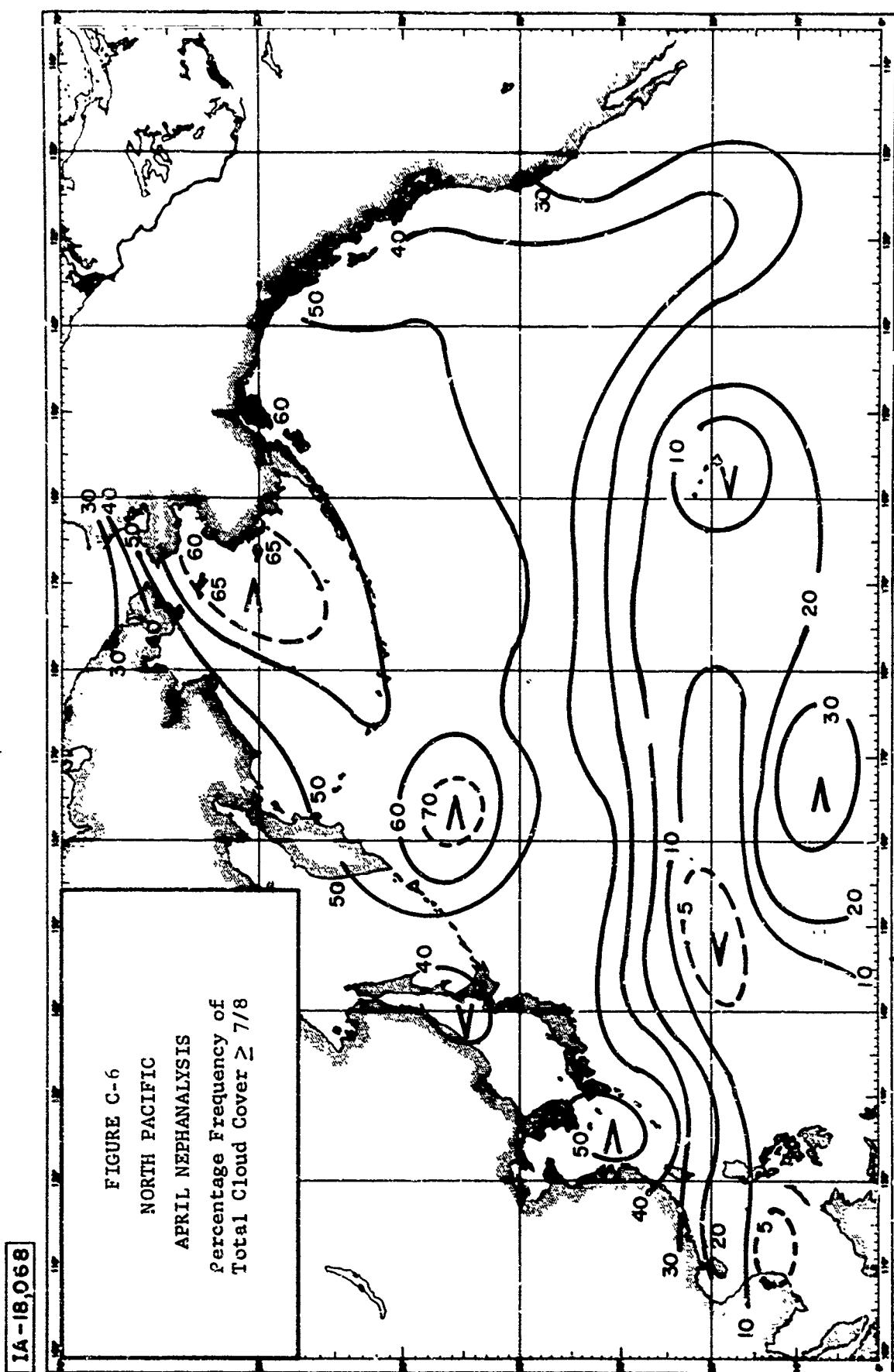


IA-18,067

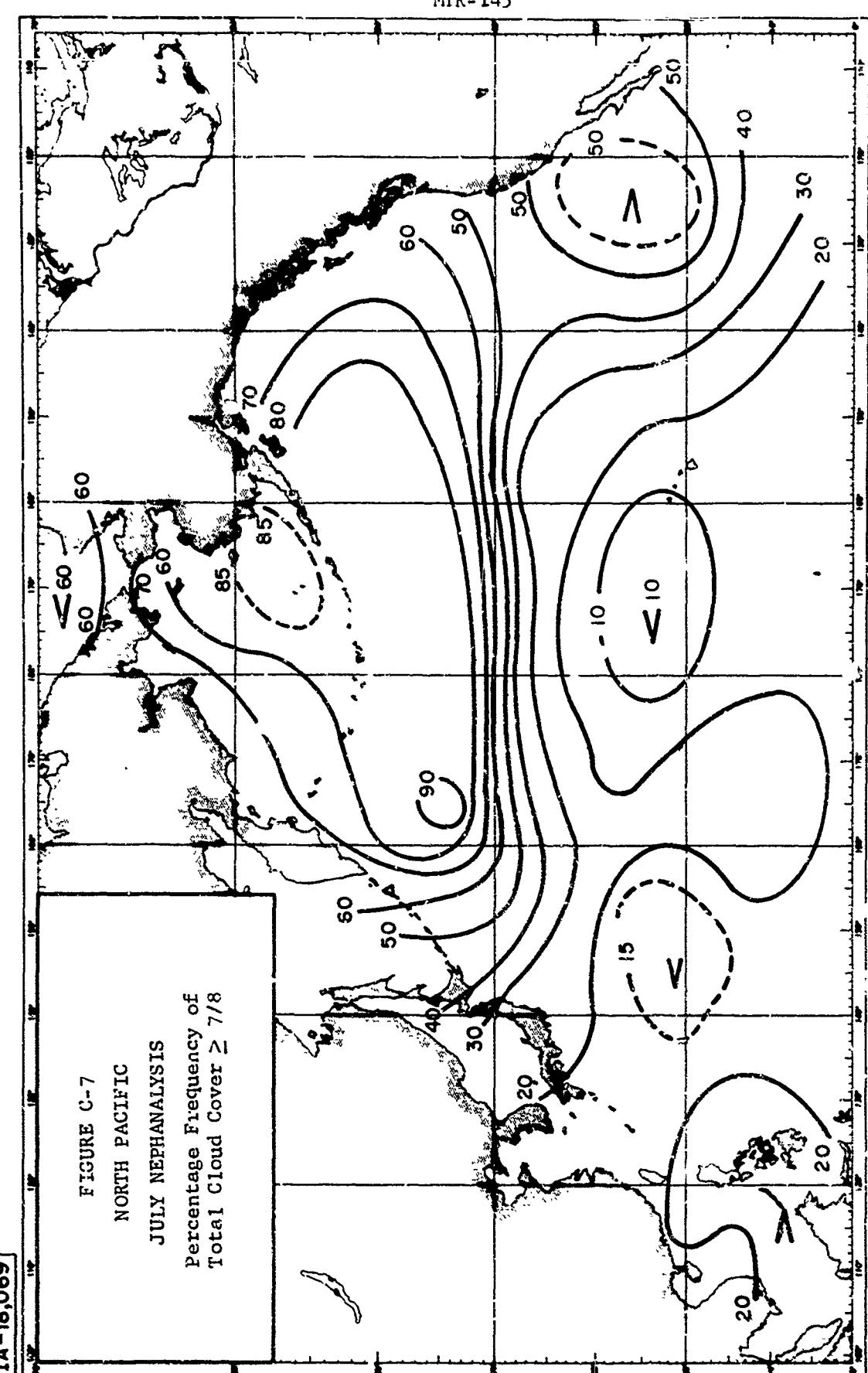
MTR-145



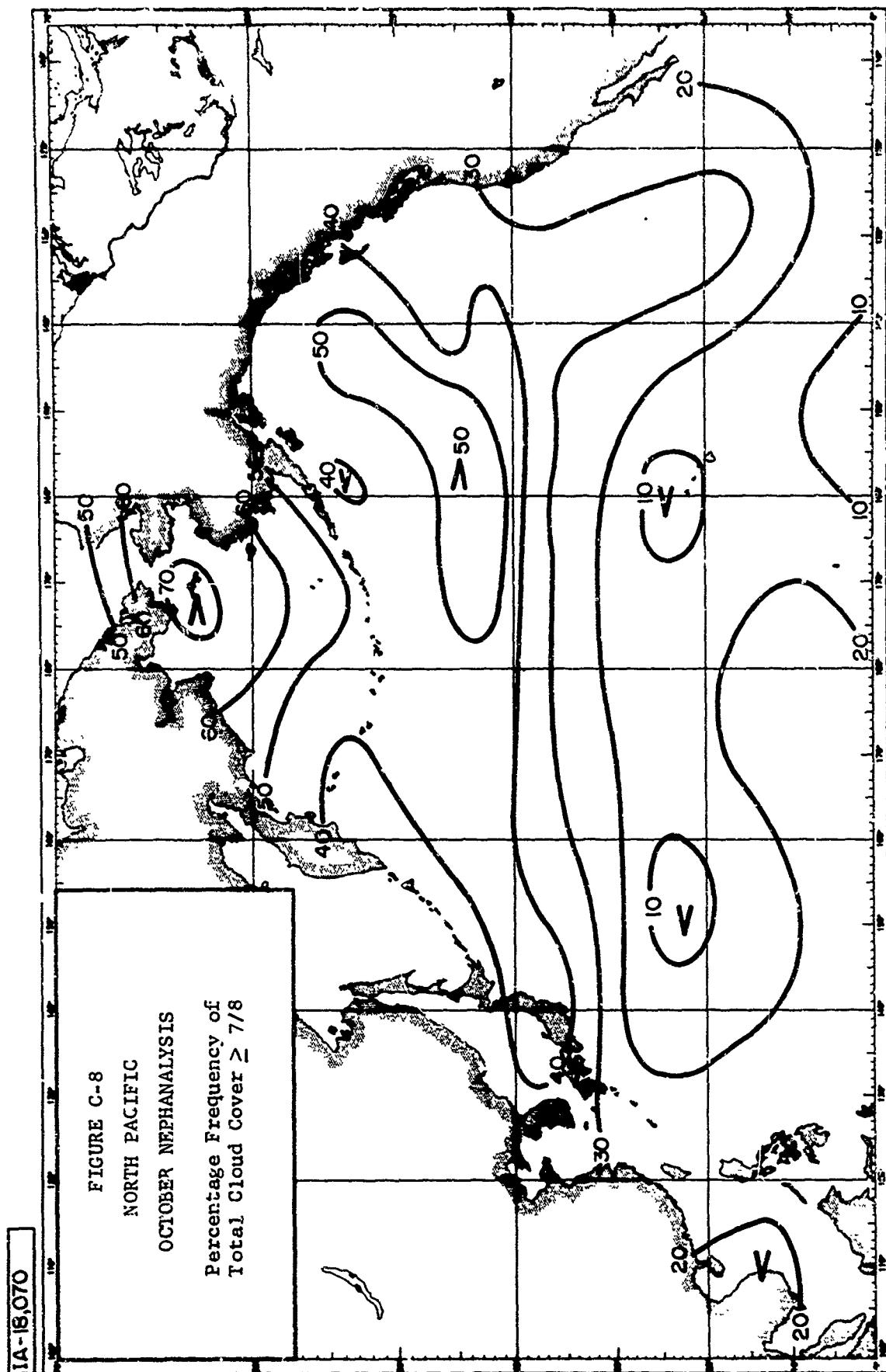
MTR = 145

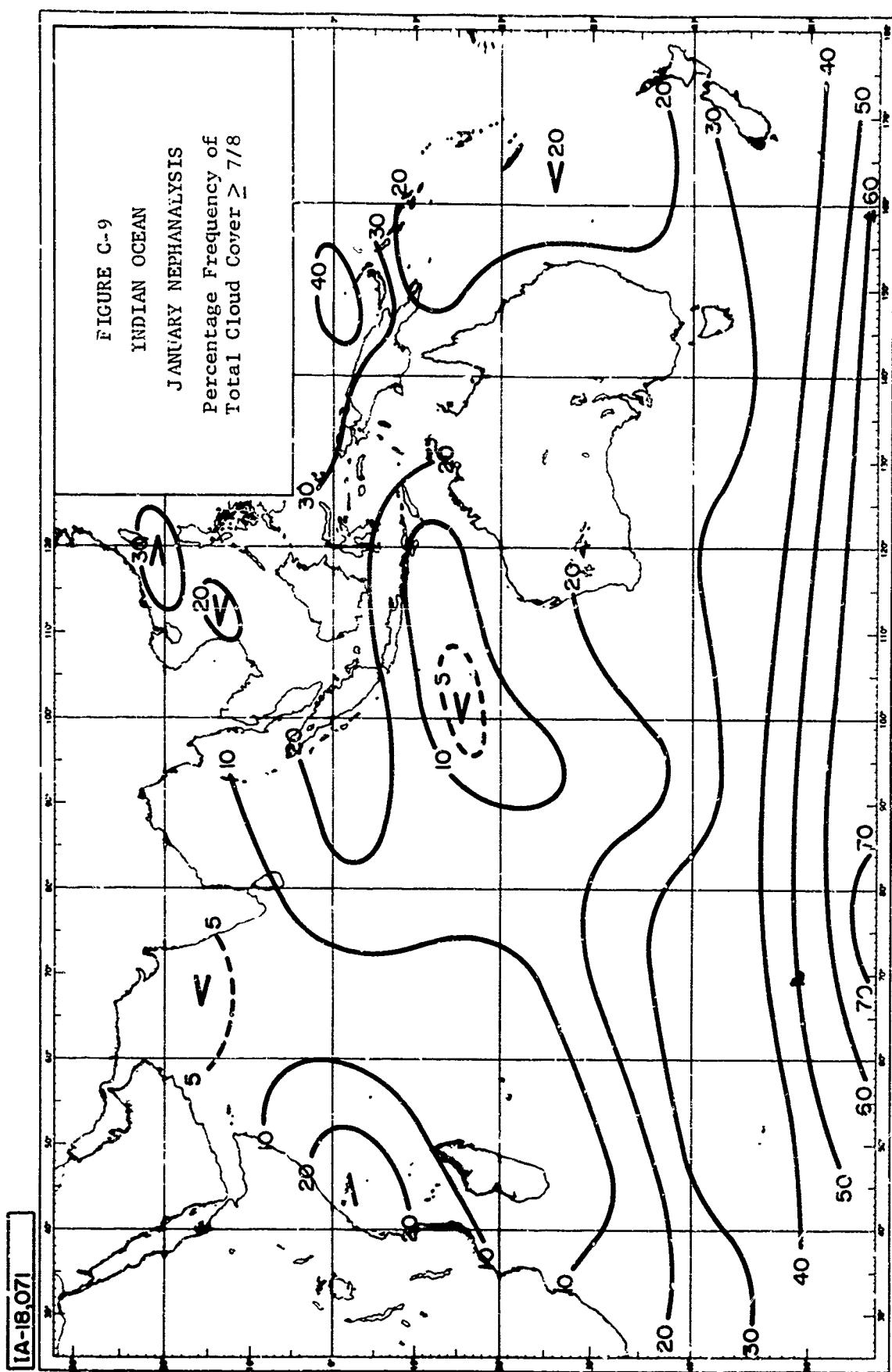


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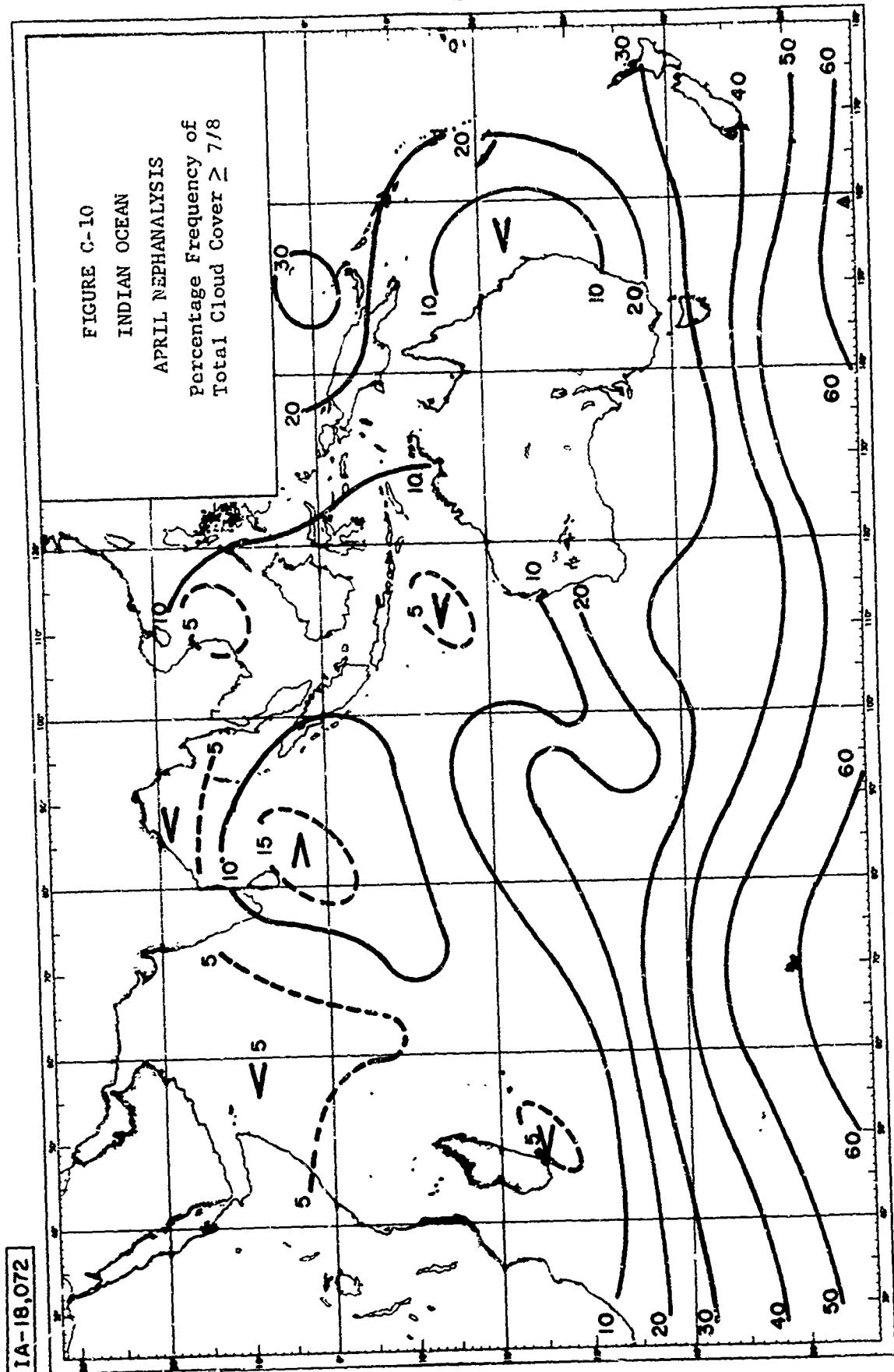


MTR-145





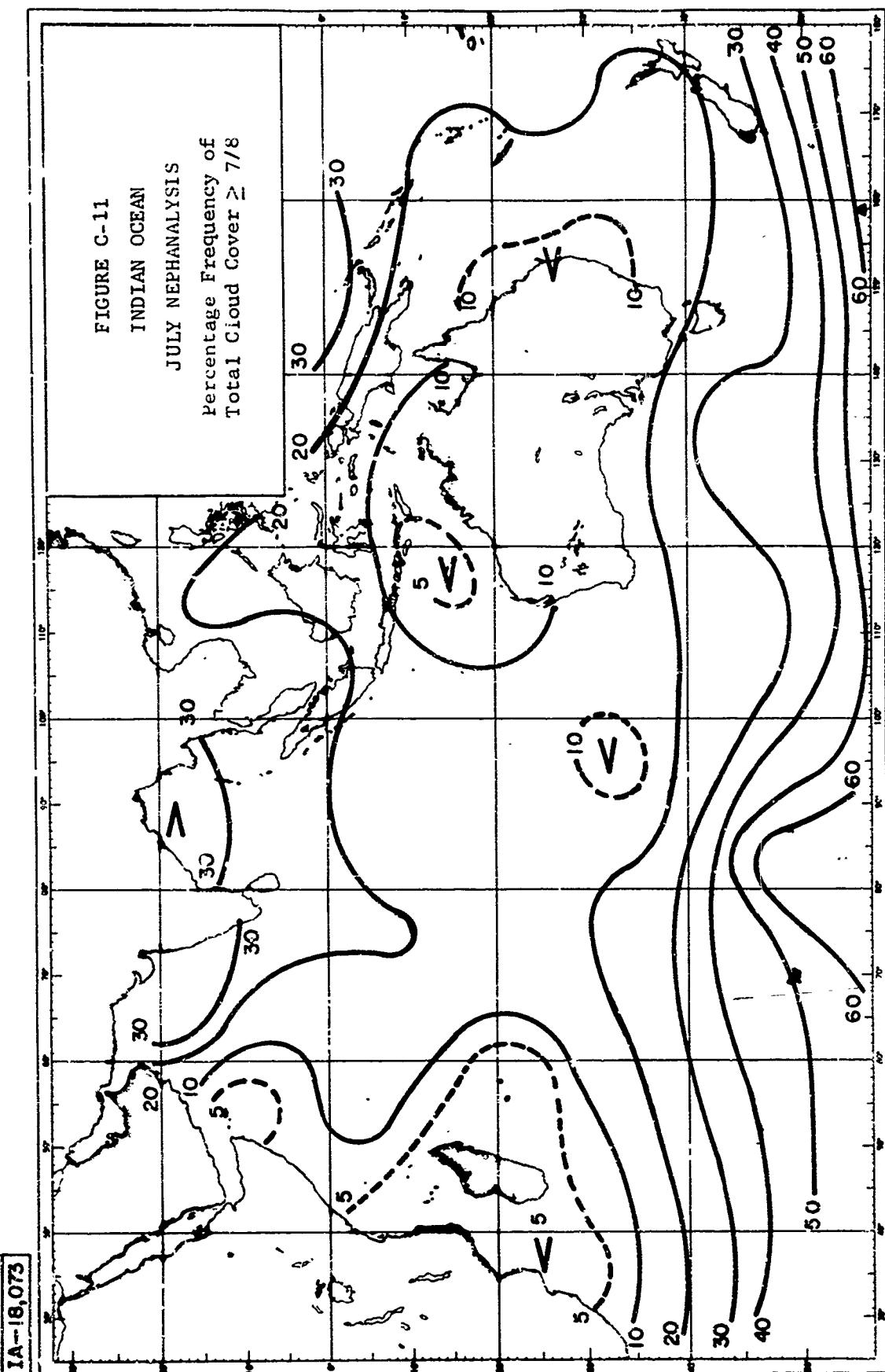
MTR-145



IA-18,072

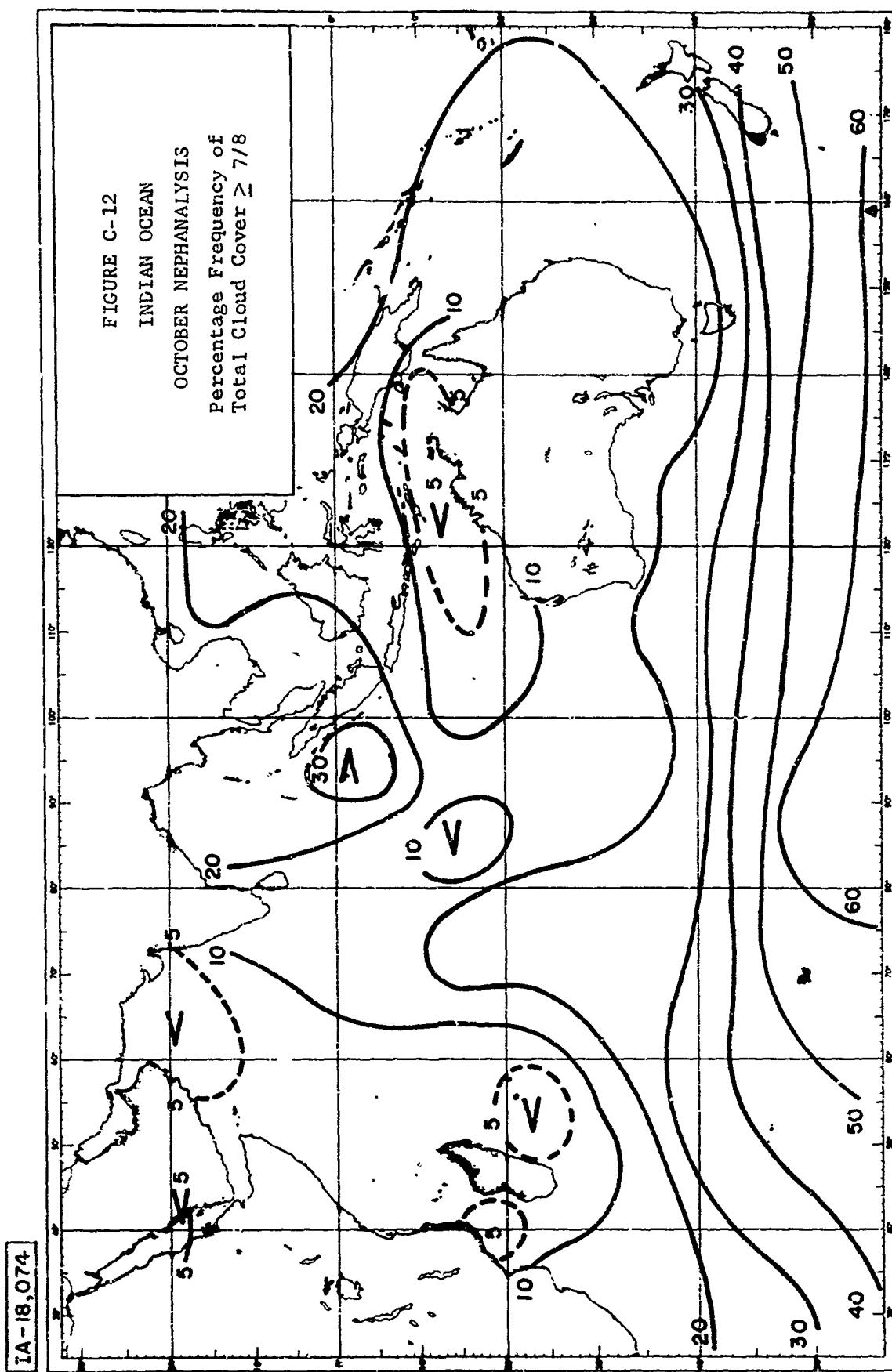
C-11

MIR-145



IA-18,073

MTR-145

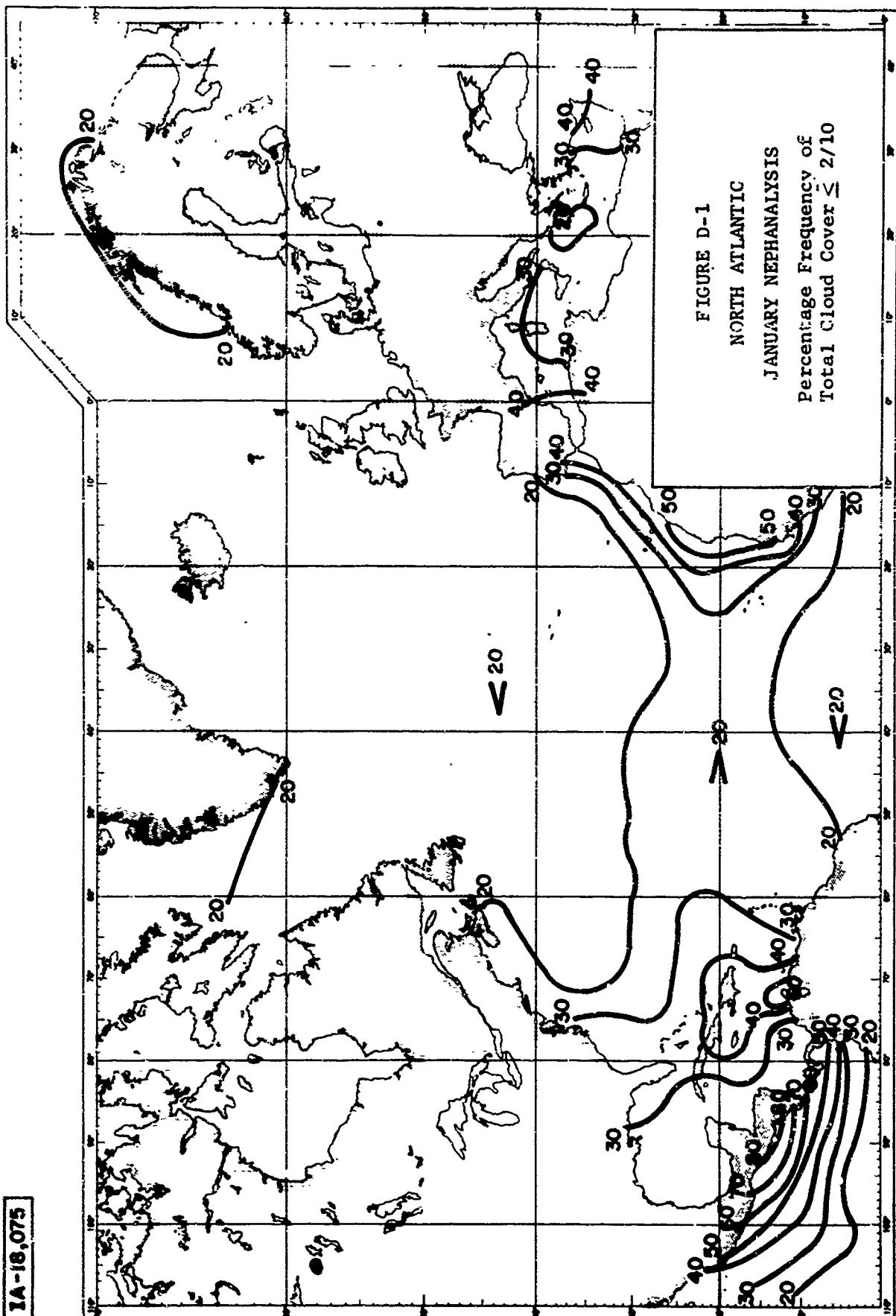


C-13

APPENDIX D

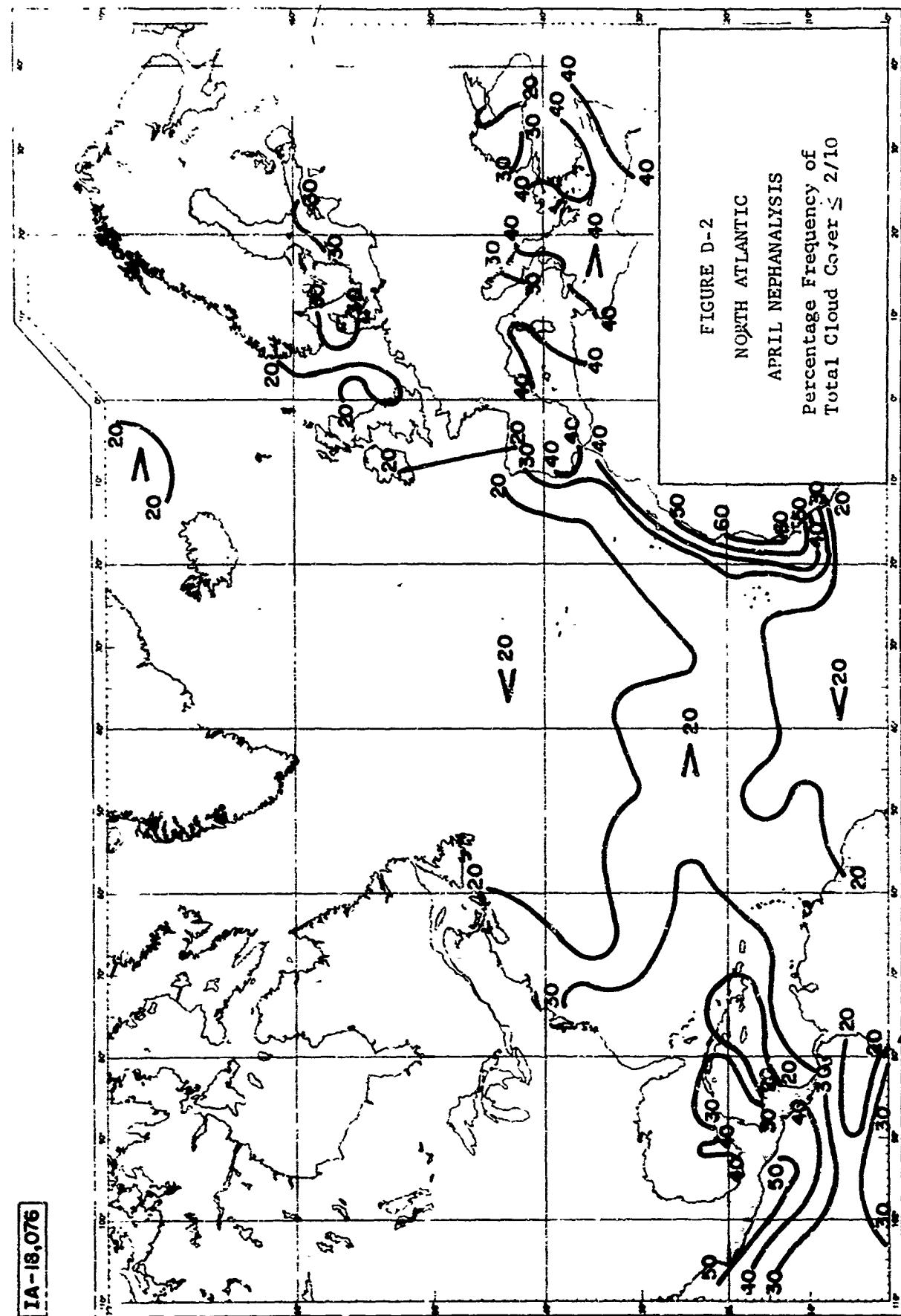
NEPHANALYSIS - PERCENTAGE FREQUENCY OF TOTAL CLOUD COVER $\leq 2/10$

MTR-145



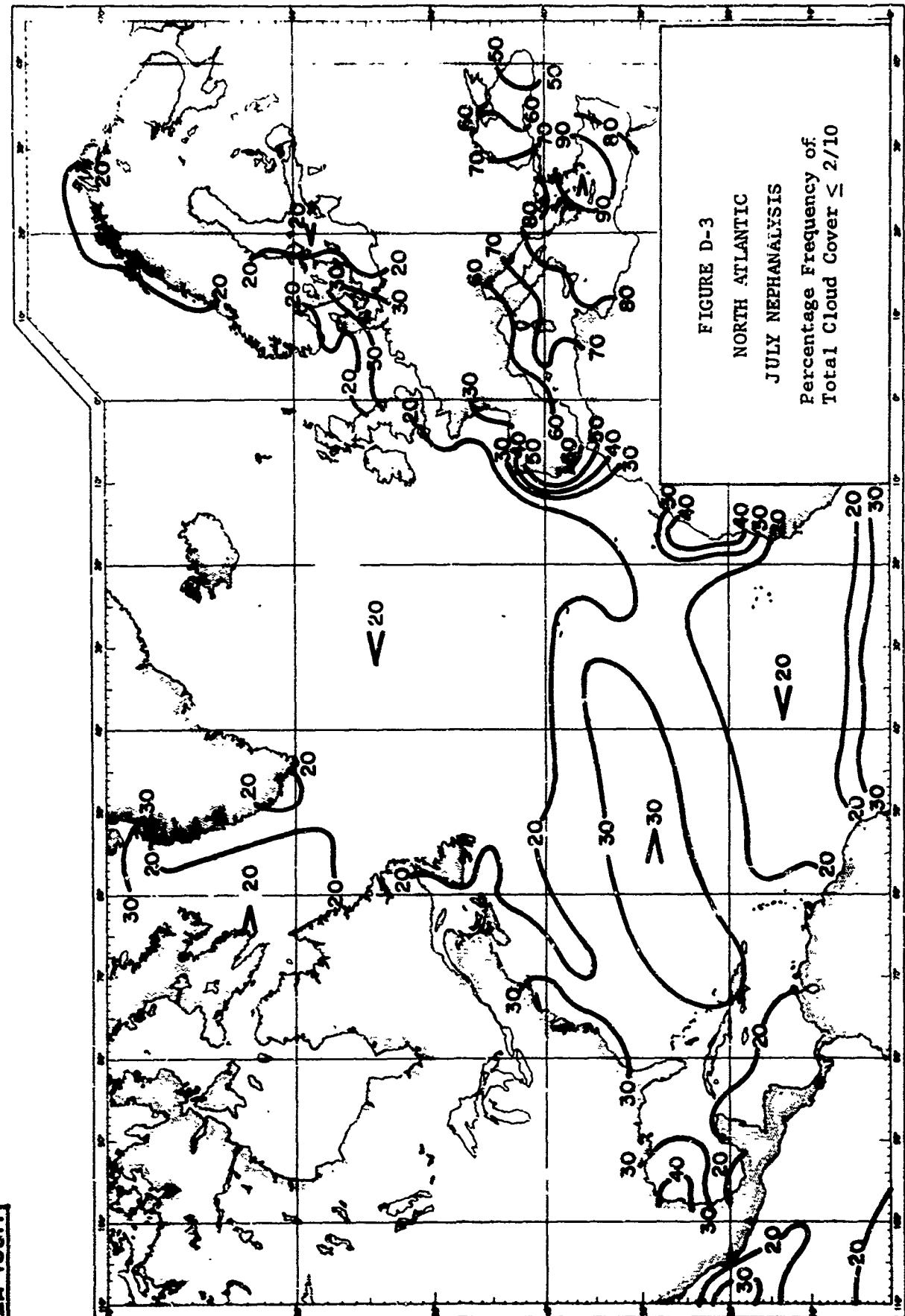
TA-18,075

MTR-145



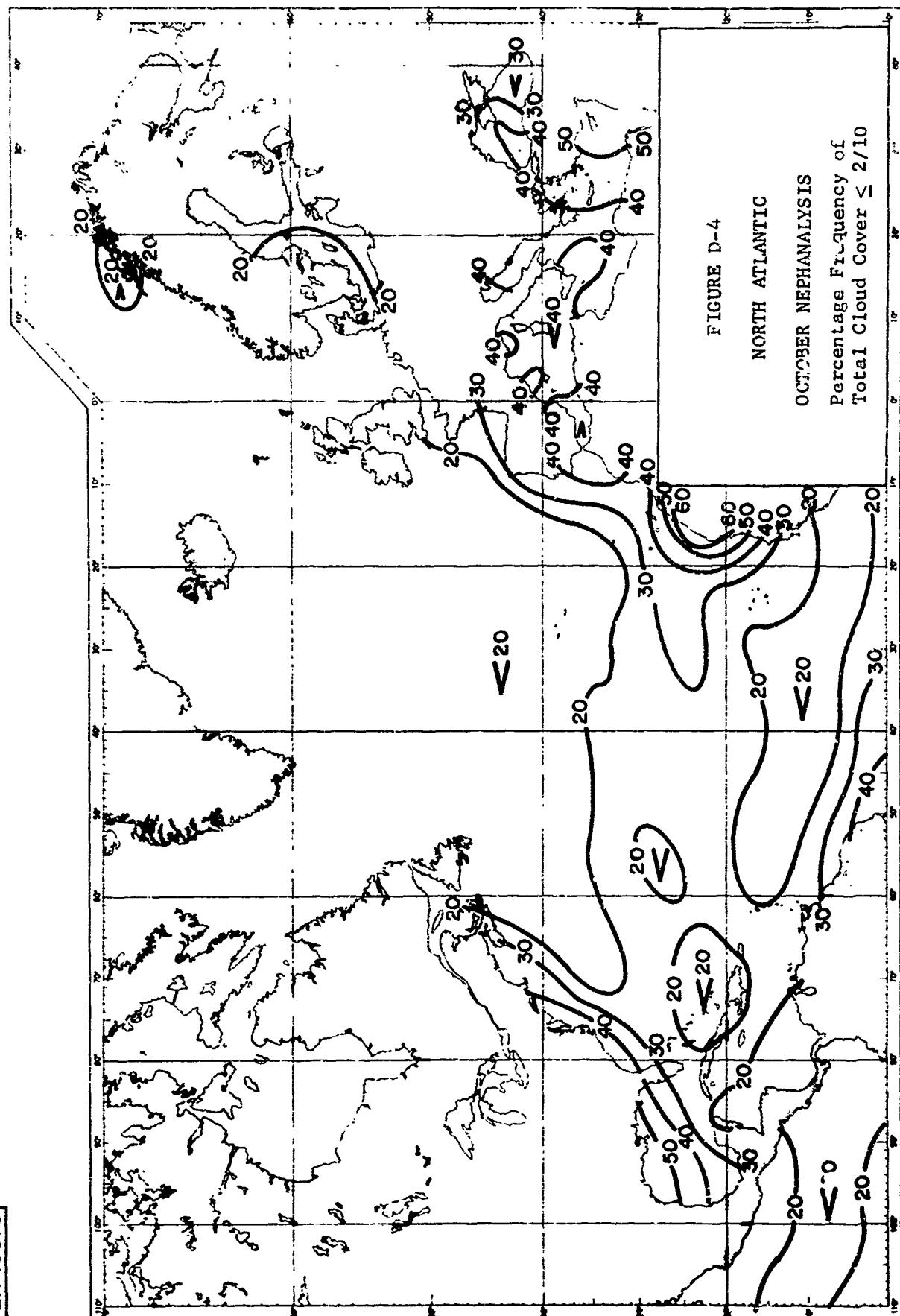
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MTR-145



IA-18077

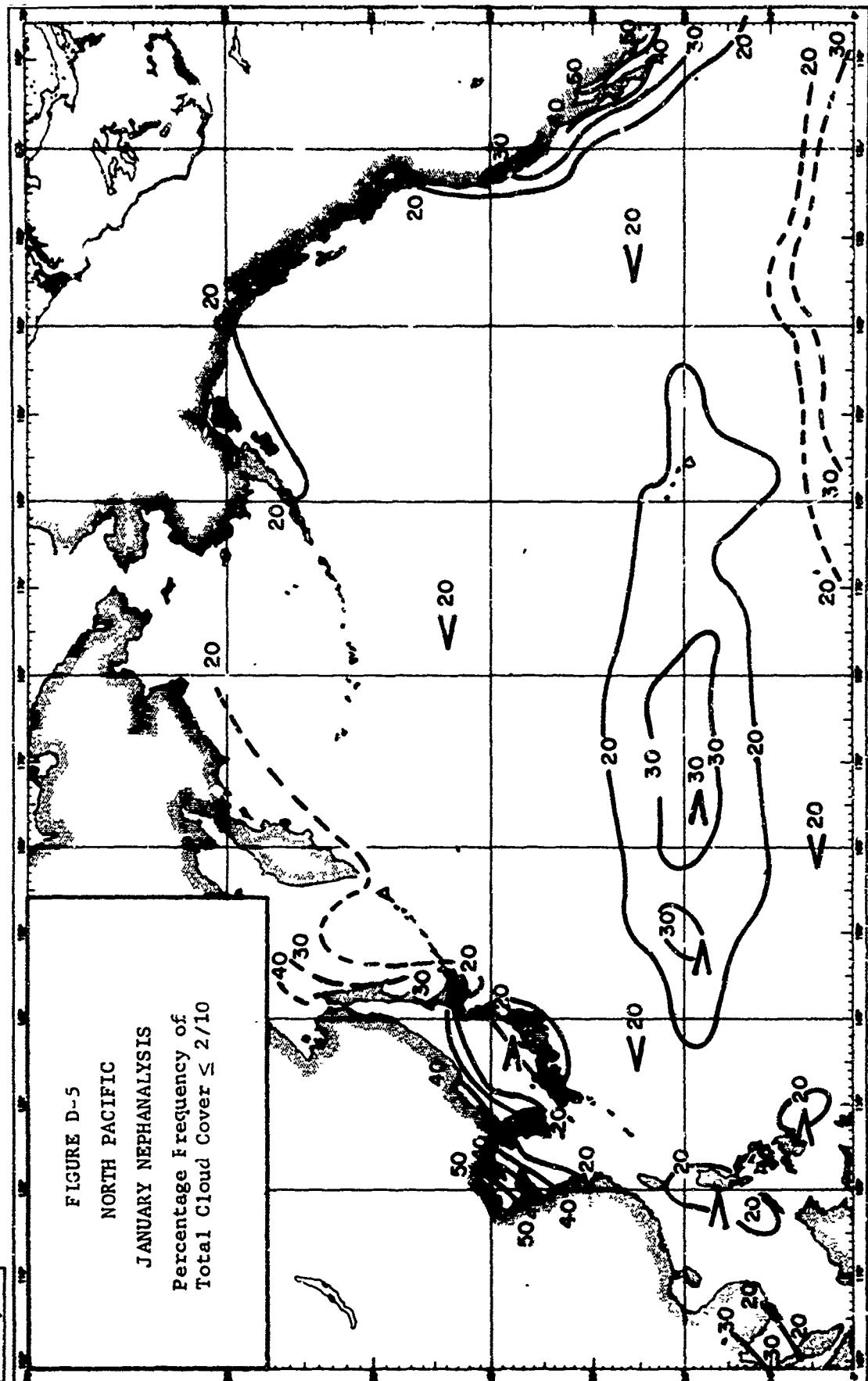
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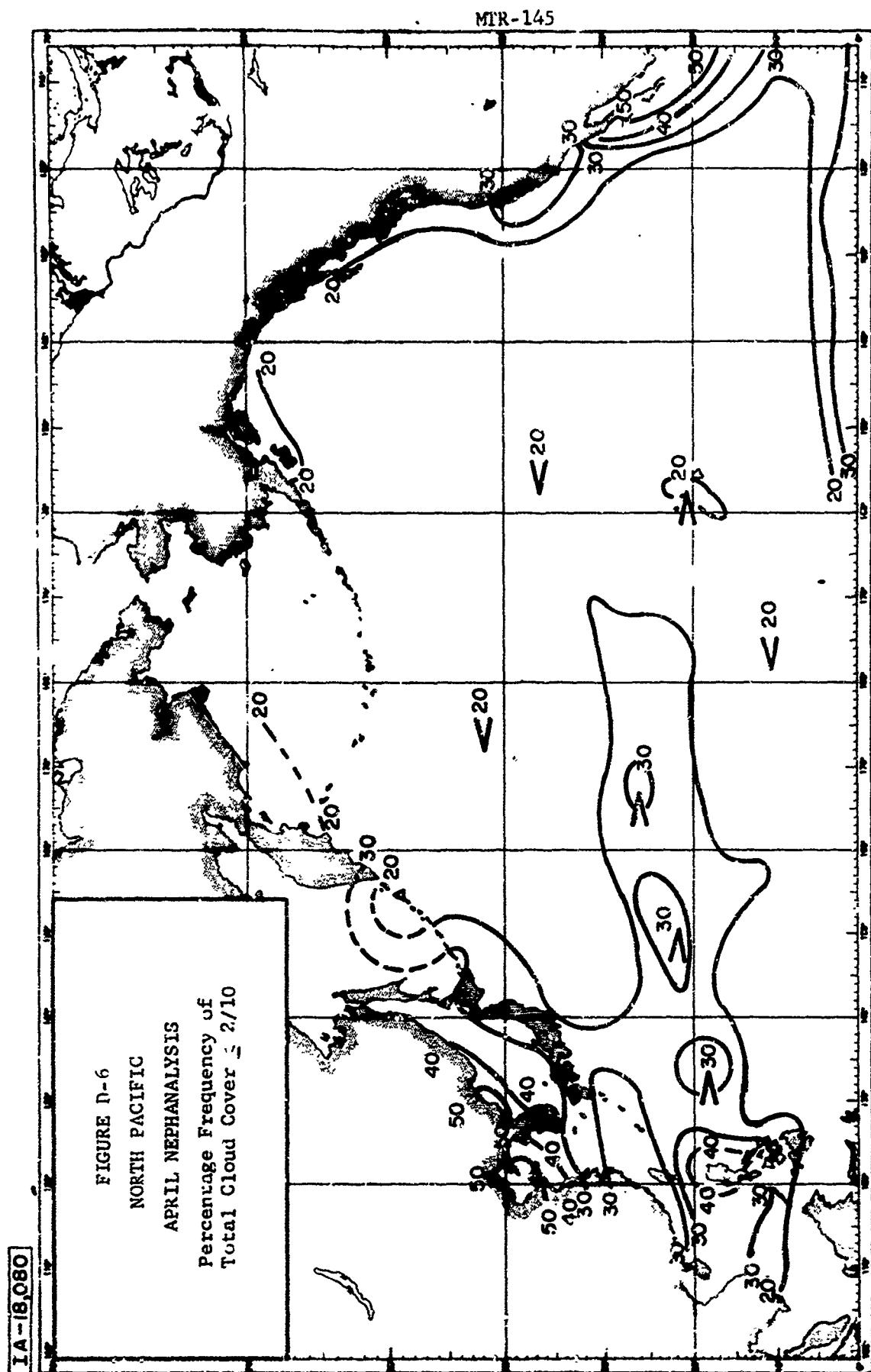


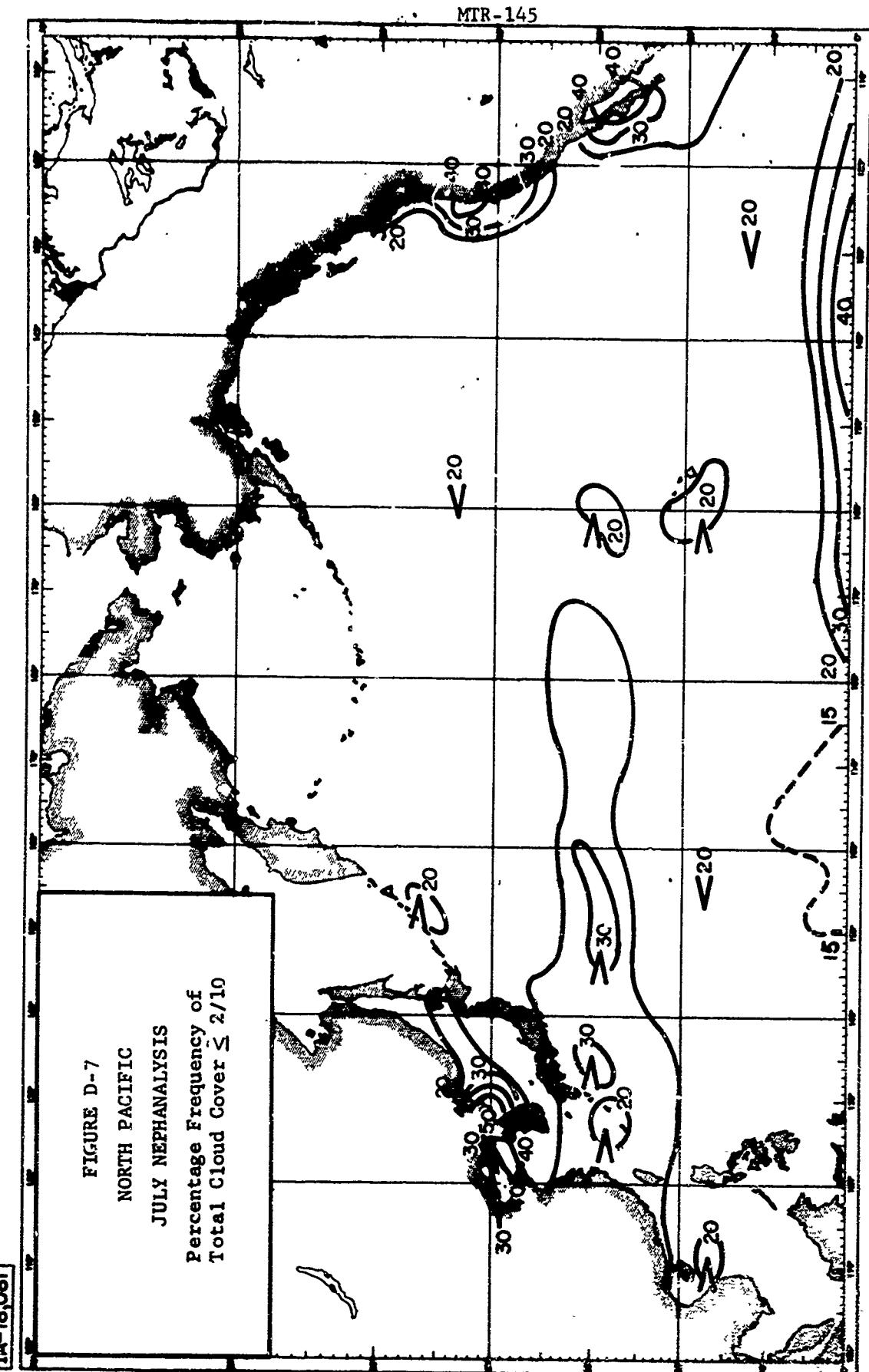
IA-18078

IA-18,079

MTR-145

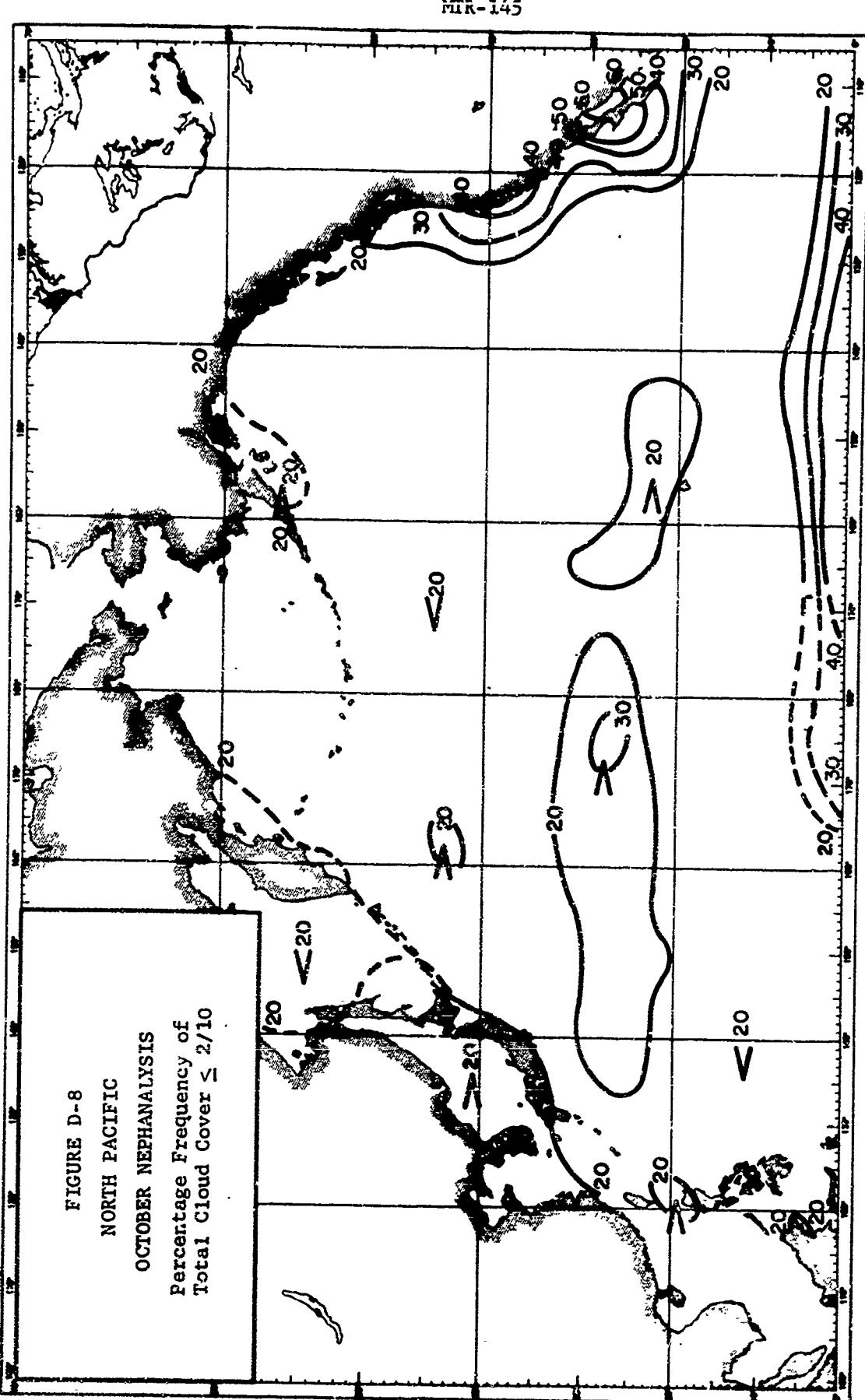






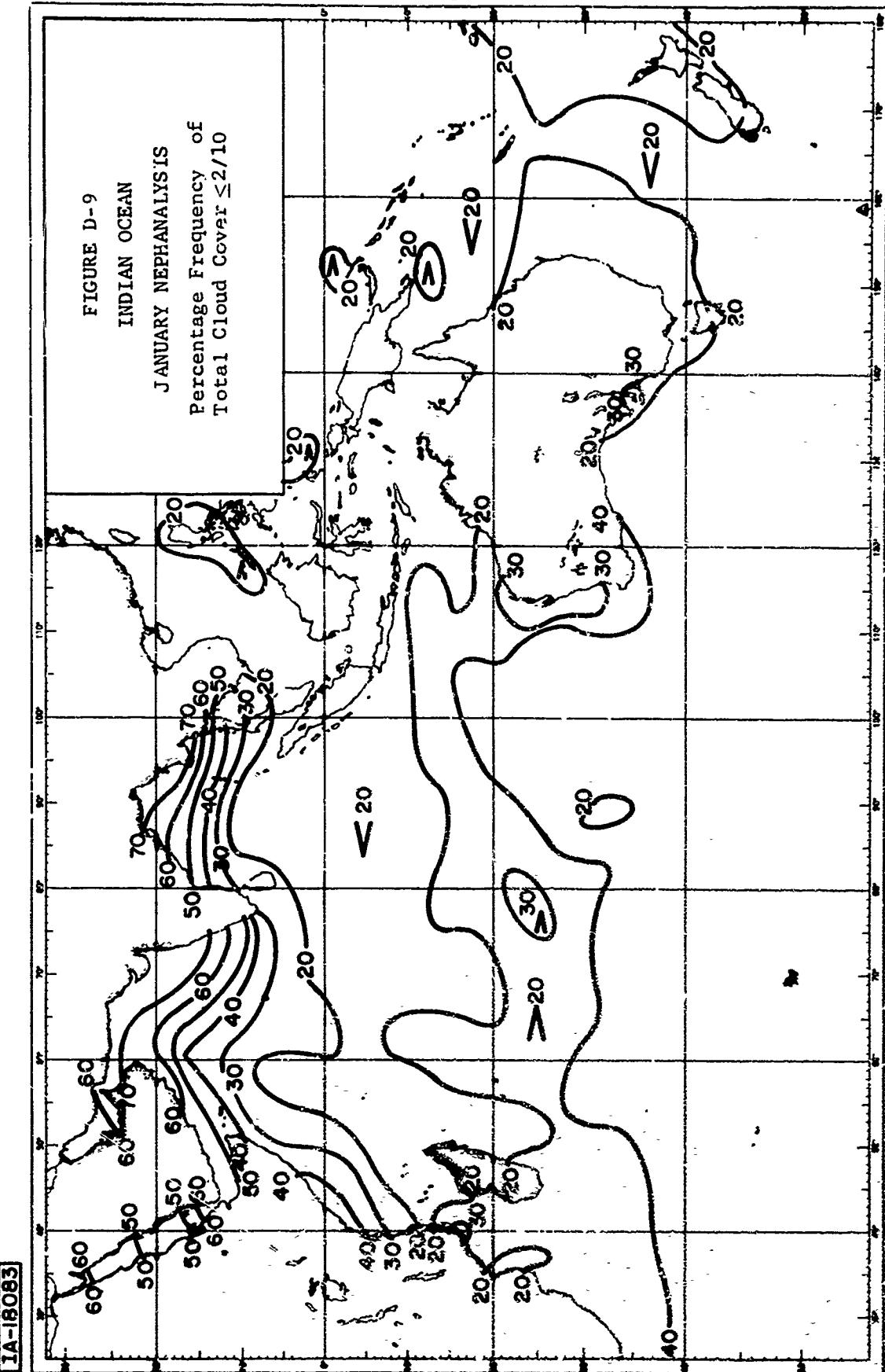
IA-18,082

FIGURE D-8
NORTH PACIFIC
OCTOBER NEPHANALYSIS
Percentage Frequency of
Total Cloud Cover $\leq 2/10$

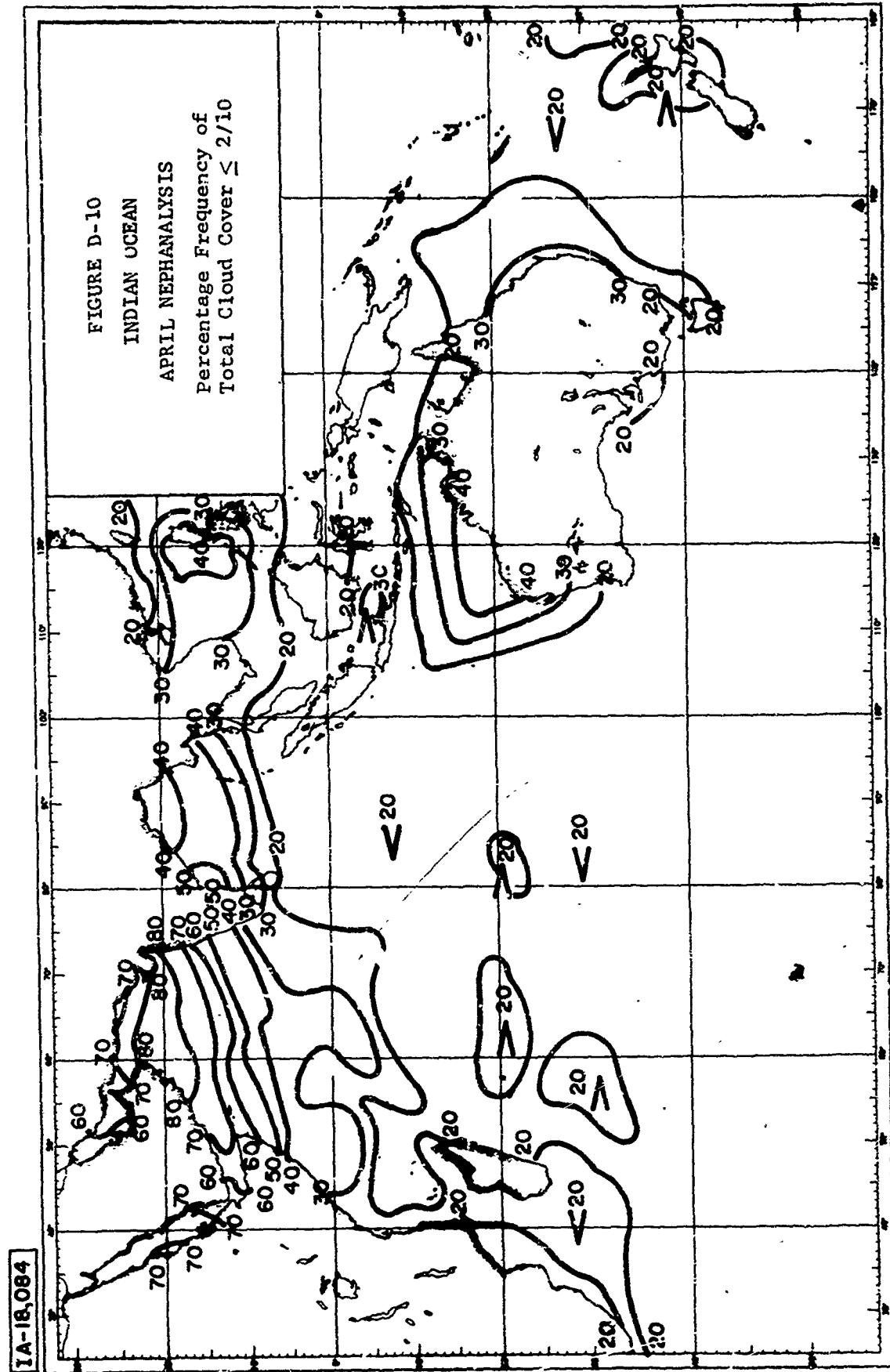


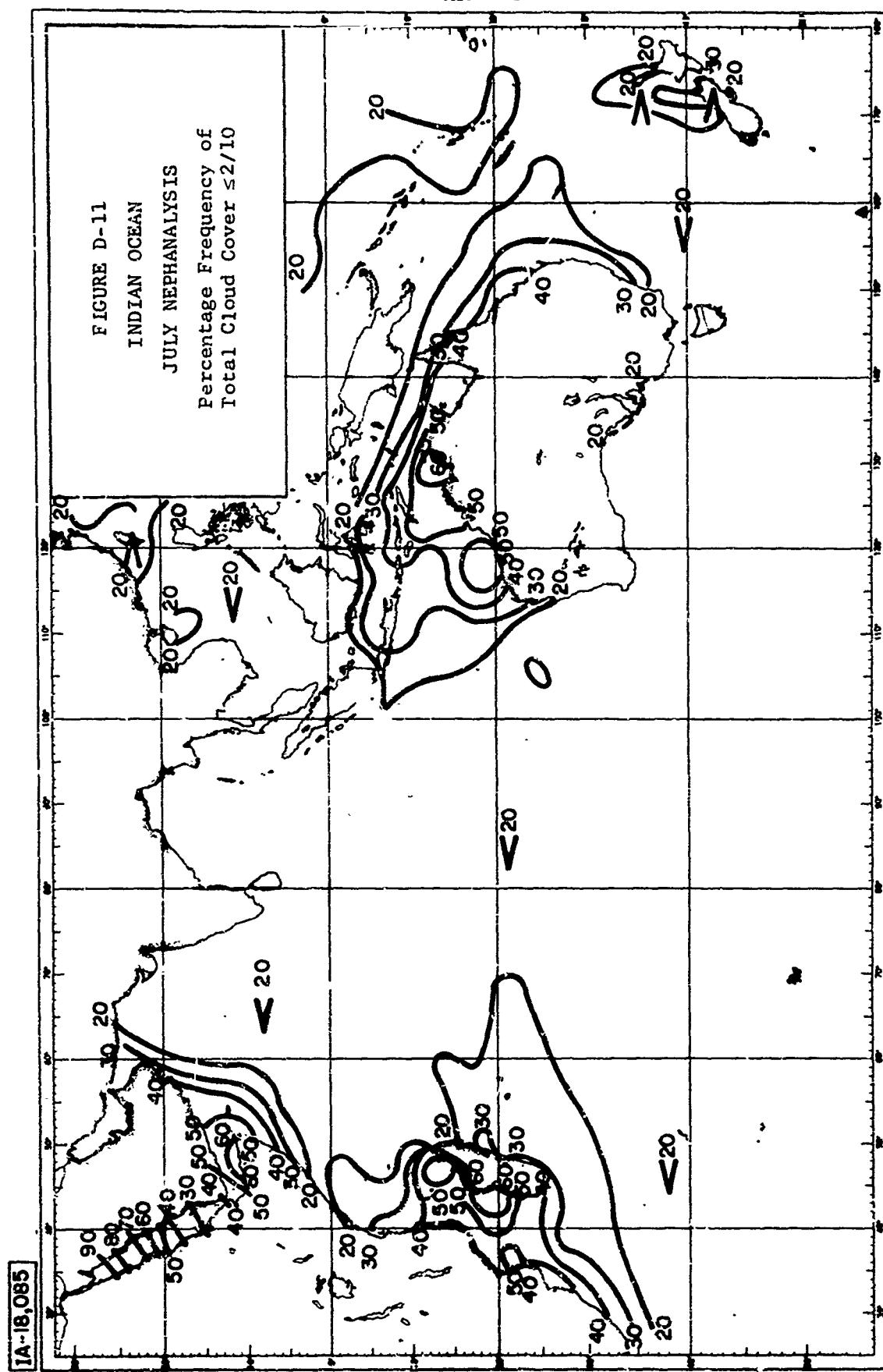
MTR-145

FIGURE D-9
INDIAN OCEAN
JANUARY NEPHANALYSIS
Percentage Frequency of
Total Cloud Cover $\leq 2/10$

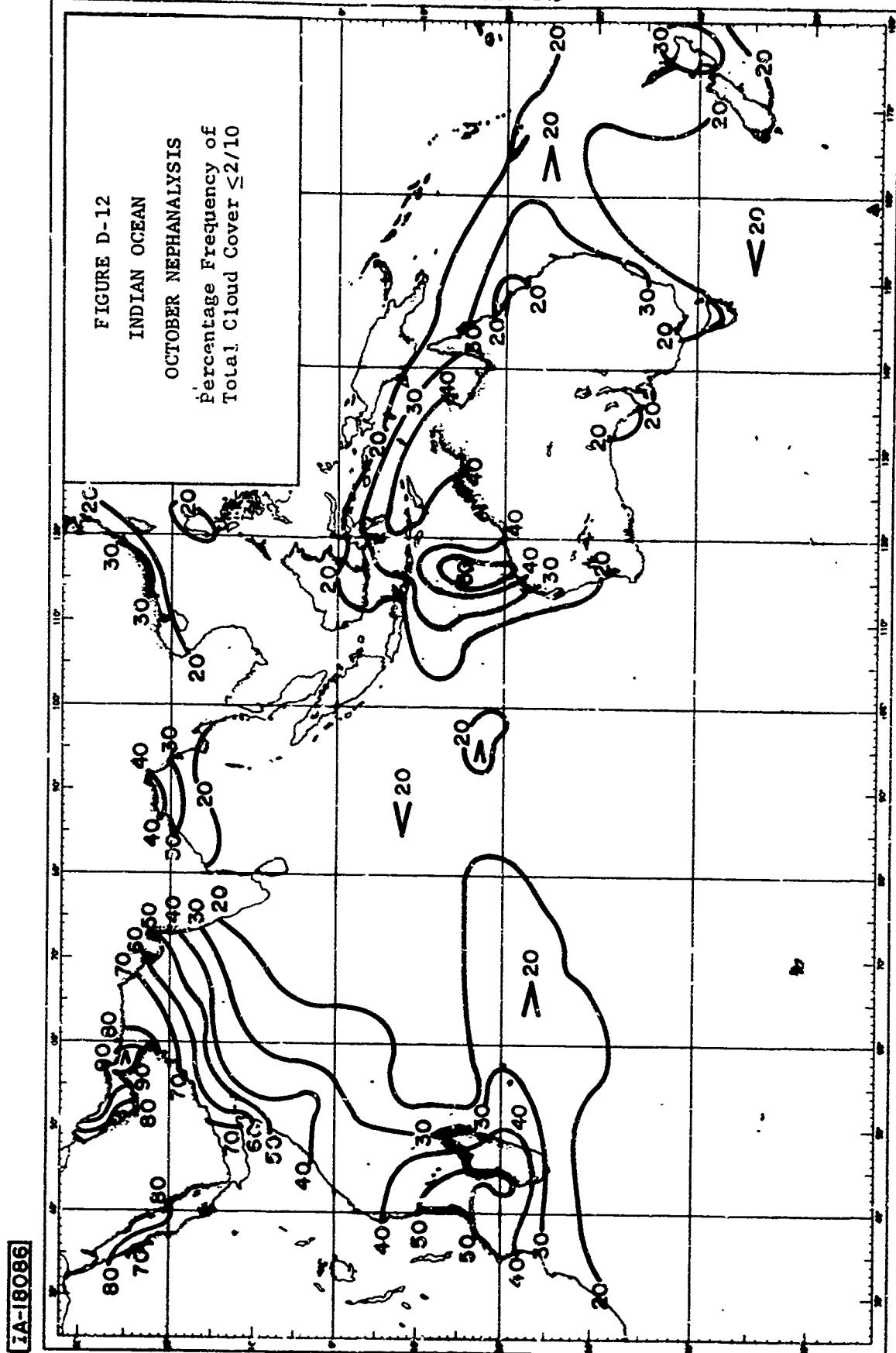


IA-18083





MTR-145



IA-18086

APPENDIX E

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